DOCKTON ROAD PRESERVATION PROJECT
PHASE 1 GEOTECHNICAL REPORT
PROJECT NO. 300208
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TO: Gwen Lewis, Engineer III, Bridge and Structural Design Unit,
Engineering Services Section

VIA: Alan Corwin, P.E., Materials Engineer, Materials Laboratory,
Project Support Services Group

FM: Doug Walters, P.E., Engineer III, Materials Laboratory,
Project Support Services Group

RE: **Dockton Road Preservation Project Phase 1 Geotechnical Report**

In accordance with your request, we have completed a Phase 1 Geotechnical Report for the Dockton Road Preservation Project. The purpose of this report is to provide the baseline geologic and geomorphic setting of the project site in order to aid alternative evaluation and selection.

We trust this information meets your current request. If you have any questions or require clarification, please contact Doug Walters at (206) 296-7708 or Alan Corwin at (206) 296-7711.

cc: Cyrus Shahrivar, E.I.T., Engineer II, Bridge and Structural Design Unit

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1.0 BACKGROUND

1.1 Introduction

The Dockton Seawall is a 3,950 foot long timber pile and lagging bulkhead that protects and supports Dockton Road SW, a minor arterial located on the eastside of Vashon Island, King County. The majority of the original timber bulkhead, constructed in 1916, has failed over the years and is now supported with boulders, chunks of concrete, and plywood. Much of the structure is approaching the end of its functional life and can no longer be maintained in a cost effective manner. Six preliminary alternatives have been identified as potential solutions to address the severely deteriorated bulkhead. The alternatives range from road removal and complete shoreline restoration to construction of a new roadway and seawall. Figure 1, immediately following the text, shows the general site location.

1.2 Purpose

The purpose of this report is to provide the baseline geologic and geomorphic setting of the project site in order to aid alternative evaluation and selection.

1.3 Project Setting

The project is located on Dockton Road SW between Portage Way Southwest and Southwest Ellisport Road, immediately north of Maury Island. The roadway is generally aligned south to north and was constructed on embankment fill at the toe of a steep beach bluff. The paved section consists of two lanes with minimal shoulders, approximately 22 feet in total width. A saltwater marsh and adjacent lowland is present on the west side of the roadway from Portage Way SW to Highland Avenue SW. North of Highland Avenue, the topography rises to a steep well vegetated bluff that typically ranges from 30 to 60 feet in elevation above the roadway. At the north end of the project, the bluff descends downward into the Ellis Creek Natural Area adjacent to Ellisport Road.

The Dockton Seawall forms the landward boundary of the saltwater beach at Tramp Harbor. The seawall protects the road and adjacent bluff from erosion and scour and provides lateral support to the roadway subgrade. The roadway is approximately 8 feet above the adjacent beach elevation. The beach is classified as mixed sand and gravel composition (Finlayson, 2006) with much of the natural beach substrate covered with concrete and rock debris from past bulkhead failure and repair.

1.4 Methodology

Geologic data for this report was primarily obtained from existing geotechnical and geological publications and studies. In addition, several field visits were conducted to identify soil exposures and areas with visible slope stability issues. In addition, hand holes were excavated at intermittent beach and bluff locations to assess the existing near surface soil conditions.

1.5 Study Area

To assess soils and geology that may be impacted by the proposed alternatives, the study area was defined as everything within one-quarter mile of the proposed project corridors. This would allow determination of site-specific and regional issues associated with the proposed road alternatives. For instance, road removal and complete beach restoration to a natural state could potentially affect the stability of the steep bluff and upland properties well outside the existing road right-of-way.

2.0 GEOLOGY

2.1 Geologic Setting

Vashon Island is located within the Puget Lowland physiographic province of the Puget Sound Basin. Within the Puget Sound Basin, the Puget Lowland occupies a north-south trending depression that is situated between the Olympic Mountains to the east and the western slopes of the Cascade Mountains. The Puget Lowland extends north to the San Juan Islands and as far south as the lower Columbia River along the Washington-Oregon border.

During the Pleistocene Epoch, the Puget Lowland was subject to at least several periods of extensive glaciation of the Cordilleran Ice Sheet that flowed repeatedly from ice originating in the mountains of British Columbia. The last major glaciation of the Cordilleran Ice Sheet, known as the Fraser Glaciation, started about 20,000 years ago and lasted about 10,000 years. It consisted of several stades (ice advances) and interstades (ice retreats). The largest and most significant glacial episode, termed the Vashon Stade of the Fraser Glaciation, advanced into the Puget Lowland as far as 15 miles south of Olympia, WA.

Puget Sound is the deepest estuarine system in the contiguous United States. Its main channel presently extends more than 600 feet in depth and may have extended to over 1800 feet in depth at the time of the last glaciation (Lavelle et al). Geologic evidence suggests most of the present day geomorphic features observed throughout the Puget Sound Basin, including Vashon Island, are attributed to the Vashon Stade of the Fraser Glaciation.

2.2 Surficial Geology

Multiple ice-sheet glaciations and intervening nonglacial intervals formed a complex layered sequence of deposits that underlie Vashon Island to depths of over 900 feet below sea level (Booth, 1991). Sediments from the Fraser Glaciation are widely exposed throughout Vashon Island while surface exposures of older glacial deposits are limited to areas such as bluffs, river valley walls, and beaches. Due to the similarities in depositional environments during the glaciations, regional correlation of Pre-Fraser glacial deposits is still an evolving effort.

The following geologic descriptions were primarily developed from information provided in USGS mapping (Booth, 1991), the Vashon Island Ground Water Management Plan (Vashon-Maury Island Ground Water Advisory Committee (VMIGWAC, 1998) and GeoMapNW (Booth and Troost, 2006). Mapping of surficial geologic units is provided in Figure 2. Based on available information, in order from youngest to oldest, surficial deposits identified in the general area of the project site are as follows:

Holocene Postglacial Deposits

Artificial Fill (af): Gravel, sand, and silt and other materials placed as a direct result of human activity and of substantial areal extent or thickness. The portage area between Maury Island and Vashon Island is mapped and known to be an area of extensive fill. In addition, though not mapped, the entire road prism underlying Dockton Road SW consists of silty sand and gravel fill to an average depth of 7 feet below the road surface.

Beach Deposits (Qb): Gravel, sand, pebbles, and shells deposited or reworked by wave action. Beach deposits are only shown on the map where they lie three to six feet above the mean high tide. Therefore, mapping only shows local deposits near the southern end of the project near Portage. Though not shown on the map, beach deposits are present and continuous around Vashon Island. The majority of the beach deposits adjacent the project site consists of poorly graded medium sands, coarse gravels, and shells. However, beach deposits consisting primarily of finer sands and shells are found adjacent the last several hundred feet of roadway at the north end of the project site.

Wetland Deposits (Qw): Wetland deposits are typically comprised of peat and alluvium that is poorly drained and annually wet. Though not identified on the map, a two-foot thick peat layer was encountered in previous King County subsurface borings near the Portage Saltwater Marsh at the south end of the project.

Alluvium (Qal): River and stream deposits of moderately sorted sandy silt, pebbly sand, and cobble gravel, and cobble. Sediments may also consist of organic rich clay, silt, and fine sand. Though not identified on the geologic map, Ellis Creek provides non-glacial alluvial deposits at the north end of the project boundaries.

Pleistocene: Vashon Stade of Fraser Glaciation Deposits

Recessional outwash (Qvr): Recessional outwash (Qvr):
Though not identified on the map, a bluff exposure characterized as a recessional deposit, consisting of stratified fine silty sand to sandy silt, was observed in the steep bluff above Dockton Roadway during a site visit on March 13, 2009. The recessional deposit was exposed by a recent surficial slide located approximately 800 feet north of the Tramp Harbor Dock and was about 20 feet in elevation above the roadway.

Till (Qvt): Mainly compact diamict with sub-angular to rounded clasts, glacially transported and deposited. Till is the predominant near surface geologic unit that covers approximately 75% of Vashon-Maury Island. The unit is typically less than 100 feet thick and forms and undulating layer across the island (Booth, 1991). The geology within the project area is predominately Vashon till which creates a local topographic high of about 185 feet in elevation west of Tramp Harbor Road SW south of the Ellis Creek Natural Area. Based on site observation, the bluff south of the Tramp Harbor Dock is primarily composed of till while the till cap above the lower advanced outwash unit thins or is non-existent going north of the Tramp Harbor Pier.

Advance Outwash Deposits (Qva): Well-bedded sandy gravel to more common medium and fine grained sand, generally firm and unoxidized and deposited by pro-glacial streams. Qva deposits tend to grade downward from gravelly sand to uniform medium-fine sand and typically ranges from 50 to 300 feet in thickness on Vashon Island. The base of the unit is typically placed on the Undifferentiated Deposits noted above of nonglacial origin. Advance outwash was encountered in hand holes and observed in bluff exposures adjacent Dockton Road SW north of the Tramp Harbor Dock.

Pleistocene: Pre-Fraser Glaciation Age Deposits

Undifferentiated Deposits (Qu): Advanced outwash overlies an aquitard composed of non-glacial silt and clay deposits to form the primary aquifer for Vashon-Maury Island (VMIGWAC, 1998). For this report, the aquitard has not been differentiated but may include transitional beds or older nonglacial lacustrine units associated with Olympia beds or Whidbey Formation. (Booth 1991). An Olympia bed non-glacial deposit Qcs is shown in the USGS Map of Vashon and Maury (Booth, 1991) at the base of the bluff near the Tramp Harbor Dock and was also noted in a later King County Report (Bethel, 2001). This unit is not shown on the current surficial geology map by GeoMapNW and was not observed in field visits conducted for this report.

2.3 Surface Soils

Based on soil survey data maintained on the Natural Resource Conservation Service (NCRS) website (http://websoilsurvey.nrcs.usda.gov/app/), three prevalent soil series types are found within the general project area. Figure 3 provides the United States Department of Agriculture (USDA) soil map from the NCRS website for the project area. A description of the various surface soils is provided below:

Costal Beach (Cb): This soil is typically found on tidal lands and beaches. The typical profile of this soil consists of 0 to 60 inches of poorly drained gravelly coarse sand and is sloped at an inclination of 1 to 5 percent.

Alderwood Series: The Alderwood Series is derived from the glacial till deposits that predominate the uplands of Vashon Island. A typical profile consists of 0 to 12 inches of dark brown gravelly sandy loam overlying grayish-brown very gravelly sandy loam to a depth of 60 inches. Soils in this series are characterized as moderately well drained and are found on slopes with inclinations that vary between 0 and 70 percent. Depending on the slope inclination, runoff can vary from slow to rapid with low to very severe erosion and landslide potential.

Everett Series: Everett Series soils are formed in glacial outwash areas in undulating and moderately steep terraces or terrace fronts. The typical profile consists of gravelly to very gravelly sandy loam to 32 inches overlying very gravelly coarse sand to a depth of 60 inches. Soils in this series are characterized as excessively drained and are found on slopes that have inclinations that vary between 0 and 30 percent. Depending on the slope inclination, runoff can vary from slight to rapid with slight to severe erosion potential.

2.4 Existing Subsurface Information

Information reviewed for this preliminary study was obtained from a previous King County geotechnical investigation and data collected from GeoMapNW and the Washington State Department of Ecology Well Log Database. In addition, 12 hand dug test holes were completed on 3/13/2009 in order to verify near surface soil conditions along the base of the bluff and beach. Figure 4 provides a location map of King County boring and hand hole locations. The associated logs of these test explorations and all additional subsurface explorations reviewed for this report are provided in Appendix A. A general description of the reviewed borings and hand holes is provided below.

King County Borings

King County Materials Laboratory drilled eight test borings in 1998 for a previous Dockton Road Seawall Replacement geotechnical investigation. The borings were advanced to a maximum 45.5 feet below the road surface using odex and hollow stem auger methodology. In general, seven feet of medium dense fill consisting of silty sand with gravel or gravel with silt and sand were observed overlying dense to very dense silty sands, silts, and sands with silt and gravel to the termination depths of the borings. However, a two foot thick seam of peat was encountered in Boring 1 from 7.5 to 9.5 feet below the road adjacent the saltwater marsh at Portage. During drilling, groundwater varied from four to nine feet below the road grade and is anticipated to fluctuate primarily in response to tidal changes.

GeoMapNW

Based on the GeoMapNW database, one groundwater test well was drilled in the central northern portion of the project alignment on Dockton Road SW. The six inch well is owned by King County Water District 19 and was drilled by cable tool methods to a total depth of 270 feet. In general, 13 feet of sand and gravel overlie water bearing silt, sand, and gravel to a depth of 170. From 170 feet to the termination depth of 270 feet below the ground surface, the driller described silt and clay with some gravels on the well log. The driller also noted the "dry well to be deepened in future w/ rotary rig." Though shown to be located in the road right of way at the north end of Dockton Road (Appendix A), the actual location is believed to be within the water district parcel located on the west end of Ellis Creek Natural Area.

Washington State Department of Ecology (DOE)

The database of drillers' logs from DOE was reviewed. Unlike the GeoMapNW database, no wells are shown to be located adjacent to the seawall. The 270 foot deep King County Water District test well noted above by GeoMapNW is shown by DOE mapping to be located approximately 400 feet west of the project site on the till upland. However, since DOE well locations are recorded to the quarter-quarter section, the actual well locations are not accurately known. Since the information obtained from driller logs is often times general, incomplete, or questionable, no additional effort was made to clear up the GeoMapNW and DOE location discrepancy.

King County Natural Resources and Parks Hydrologic Services Group

King County Hydrologic Services Group (KCHSG) provided a search of wells on their database for the general project area. The same King County Water District 19 well mentioned above is shown at two locations on the KCHSG mapping.

KCHSG shows locations of nine wells in the general area of interest but has no current water level data.

King County Hand Holes

Eight hand dug test holes were excavated along the beach and at the toe of the bluff to verify near surface soil conditions. In general, hand holes verified surficial geology and NCRS mapping of till, advanced outwash, and beach deposits.

2.5 Hydrogeology

Aquifers

Precipitation is the only source of recharge to the groundwater system on Vashon Island. The surficial geology plays a major role in the amount of precipitation that infiltrates the ground to become recharge. Likewise, the surficial geology and infiltration potential helps define the susceptibility of the groundwater system to water quality impacts and the ease with which contaminants can move in the subsurface. The characteristics of the geologic strata, whether they are fine-grained or coarse materials, compacted or loose, depend on the depositional environment at the time of placement. These characteristics in turn define the flow potential of the units. A geologic conceptual model showing a generalized bluff cross section is provided in Figure 5

The information for this section was largely derived from the Vashon-Maury Island Groundwater Management Plan (VMIGWAC, 1998) and data provided by the King County Groundwater Protection Program. This discussion is limited to the aquifers found in the primary geologic units considered in this evaluation and does not examine the deeper aquifers that underlie Vashon-Maury Island.

Vashon Advance Aquifer: Qva

The Vashon Advance Aquifer is the primary aquifer for Vashon-Maury Islands and occurs in the geologic unit of the same designation. Nearly all groundwater supply wells on Vashon-Maury Islands derive their water from this unit (VMIGWAC, 1998). Where present, glacial till overlying the Qva provides a natural protective layer against groundwater contamination. However, where exposed in areas along stream channels or bluffs, the Qva is highly susceptible to contamination due to its high permeability and recharge potential. Based on cross sections provided on USGS Mapping (Booth, 1991), the base of the outwash varies in elevation from over 200 feet at the north of the Island to approximately 50 feet below the sea level in the general area between Vashon and Maury Island. Therefore, the Qva aquifer in the project area appears to be in direct connection with Puget Sound.

Surficial-Interflow Groundwater Systems: Qvt

Water that occurs in the more porous portions near the top of the till layers (Qvt) is referred to generically as the Interflow Aquifer System since it holds water for surface water systems such as wetlands and bogs. Technically, this hydrologic system is probably not an aquifer because it is discontinuous and unable to supply useful amounts of water for beneficial purposes such as an individual drinking water well. However, the Interflow Aquifer System is significant because it stores water for surface water base flow and allows recharge to proceed throughout the year in the till-mantled uplands.

Groundwater Recharge

As previously stated, precipitation is the sole source of recharge for Vashon-Maury Island groundwater. The ability to recharge the Vashon-Maury Island aquifers is directly related to the surface geologic units along with the modifications to the land surface. The Vashon-Maury Island Groundwater Management Plan (VMIGWAC, 1998) estimates that 55 percent of recharge occurs through the till while the other 45 percent of recharge occurs in the higher recharge outwash deposits that make up approximately 25 percent of the land surface area.

Groundwater Flow

Groundwater will flow from areas of high elevation to areas of low elevation. On Vashon Island, this flow is away from the central portion of the island and towards deeper aquifer units or into streams that flow ultimately to Puget Sound. In the Dockton Project area, groundwater flow is west to east and directly into Puget Sound.

Sole Source Aquifers

Sole Source Aquifers are designated by U.S. Environmental Protection Agency (EPA) under the Safe Drinking Water Act to offer protection for aquifers that are the sole or principal source of drinking water for an area. The groundwater system beneath Vashon-Maury Island is designated as a "sole source aquifer" by the (EPA). Therefore, it is critical that measures associated with any County Road Project be looked at for potential impacts to the groundwater recharge areas and impacts from potential pollution sources.

Due to the rural nature and lack of commercial development in the general project area, there are no known current potential groundwater contamination sources on Dockton Road SW. Historically, there was a Standard Oil bulk fuel facility located just south of the Tramp Harbor Dock that may be a potential source of petroleum hydrocarbon pollution. In addition, prior to the road being paved, oil was reported to have been spread on the gravel road yearly in order to control dust. Hence, soil contamination in the form of hydrocarbons may be found in the road prism of Dockton Road SW. Therefore, future subsurface borings and testing of soils near the old facility may be needed to define the levels and extent of potential contamination.

3.0 BLUFF AND SHORELINE GEOMORPHOLOGY

3.1 Bluff

The elevation and morphology of Puget Sound bluffs vary due to differences in upland relief, geologic composition and stratigraphy, hydrology, orientation and exposure, erosion rates, and vegetation (Shipman 2004). The current configuration of bluffs are generally thought to have been formed from the rise of sea levels associated with global melting of ice sheets that occurred up to 5000 years ago (Downing 1983). The bluff adjacent Dockton Road SW formed as a wave-cut terrace eroded inland from a point near the original shoreline similar to most bluffs in Puget Sound.

The geology within the project area is predominately Vashon Till which creates a local topographic high of about 185 feet in elevation at the north end of Tramp Harbor Road SW just south of the Ellis Creek Natural Area. The bluff south of the project mid-point is primarily composed of very dense till and ranges in elevation from 30 to 50 feet in height with an average slope inclination of about 60 degrees. The till cap thins or is non-existent from the midpoint of the project, north to Ellis Creek, exposing the underlying advance outwash unit. The bluff north of the project midpoint is estimated to range from 30 to 60 feet in elevation with slope inclinations ranging from 30 to 60 degrees.

Marine bluffs are subjected to wave attack and erosion at the toe of the slope, which contributes to intermittent bluff retreat through mass wasting (landslide) events such as slumps and debris avalanches (Johannessen et al 2005). Beaches in Puget Sound are predominantly an accumulation of these sediment deposits along the shore. Erosion and landslide of marine bluffs provide an estimated 90% of the beach sediment in Puget Sound with stream sediment accounting for the remaining 10% (Keuler 1988). Historically, the Dockton Road SW bluff would have been an important "feeder bluff" to the adjacent beaches of Tramp Harbor.

The construction of Dockton Road in 1916 has protected the bluff from direct wave erosion for over 90 years and virtually eliminated the associated bluff sediment deposits into Tramp Harbor. Though wave attack has been eliminated, hydrologic processes with added impacts from land use development, continue to erode the bluff and trigger episodic landslide events. Landslides often occur at the seepage zone/perched groundwater contact of a more permeable soil layer overlying a less permeable zone of soil. In general, ground and surface water entering the receiving slide zone exceeds the soils ability to drain. This creates a backup or water and the development of pore water pressures in the receiving soils. Eventually, the pore water pressures exceed the soil shear strength. Ground movements and release of excess pore water pressures occur until equilibrium is re-established. Common erosional processes impacting the bluff include soil creep, sheet wash, and landslide.

Based on conversations with King County maintenance, approximately 20 landslides have occurred along the Dockton bluff at various intermittent locations since 1984. The landslides frequency is about one every other year. The landslides have all been shallow in nature and have been triggered by either extended periods of heavy precipitation, typically January through March, or 100-year storm events such as in January of 1996. An additional contributing factor appears to be from residential development at the top of the slope which has led to increased and concentrated flows to the bluff from driveways, roofs and septic systems. Roof and yard drains discharging directly onto the steep bluff has also been a contributing factor in many of the slides.

Two shallow landslides of the bluff occurred this past year in January of 2009 after extended periods of heavy precipitation. The cause appeared to be saturation of the oversteepened and weathered slopes with possible contributions from residential drainage. For landslide repair, King County maintenance removed sloughed soils from the toe of the slope and roadway. In addition, jute matting was placed and hydroseeded in an attempt to re-establish slope vegetation. Pictures of the two recent landslides and residential drainage discharging on steep slopes can be seen in Figures 6 and 7.

Bluff recession in Puget Sound primarily depends on the wave environment, resistance of materials to erosion, and beach characteristics (Canning and Shipman 1994). The rate of natural erosion and mass wastage events that occurs on bluffs can also be greatly impacted by site development and modifications to land. Natural bluff erosion rates on costal bluffs of Puget Sound vary between 0.1 feet/year and 5 feet/year (after Shipman). Long-term average rates of recession for natural bluff backed beaches in central Puget Sound were found to be about 0.3 feet/year (Keuler 1988). Bethel (2001) estimated an average retreat rate for the natural bluff above Dockton Road at about 0.2 feet/year.

Bluff retreat from slope erosion above Dockton Road SW has been documented but no rate has been established. Based on site observation, it appears the predominantly till bluff located along the southern area of the project is retreating slower than the bluff composed mostly of advanced outwash sands and gravels located adjacent the northern portion of the project. Though not confirmed, this would be anticipated since the till is cemented and the advanced outwash sands and gravels lack cohesiveness. To verify the rate of bluff retreat, survey of the current bluff line along with annual long term monitoring would be required.

3.2 Beach Geomorphology

The three geomorphic features identified in the project area, from south to north are a barrier beach that has formed between Maury Island and Vashon Island, a bluff backed beach, and a barrier estuary where Ellis and Ellisport drainages merge (Fung and Davis, 2005). The historical source of sediment for the beach has been bluff erosion and movement of sediment by waves and currents. Sediment moved from the bluff by wave action has been concentrated at Portage and Ellisport, producing the barrier beach at Portage and the barrier estuary where Ellis and Ellisport Creeks discharge to the Sound at Ellisport.

Much of Puget Sound is considered a low energy environment and the beach is classified as mixed sand and gravel composition (Finlayson, 2006). In the vicinity of most of the bulkhead the natural beach substrate is covered by concrete slabs, rock and debris from past bulkhead failures and repair activities. The elevation of the rock debris varies from above the MHHW to approximately +3 feet and extends up to 75 feet water-ward of MHHW with the heaviest deposits within 30 feet water-ward of MHHW. The beach sediment size and profile is influenced by several factors including the road bulkhead, wave energy and tides, source material (or lack of it), structures intersecting the beach (barge dock, historic fuel dock and pier) and the rise in sea level in Puget Sound.

The bulkhead restricts sediment supply from the bluff and alters the wave energy distribution on the beach. Rather than dissipating energy by turbulence, interaction with driftwood and infiltration on the upper beach, waves hit the bulkhead and are reflected back onto the beach and off shore. This increases the amount of finer sand and sediment removed from the beach. Tramp Harbor is protected by Maury Island to the south and Heyer Point to the north. These features protect the beach from direct wave attack from the largest storms. The prevalence of low energy waves moves finer sediment but prevents larger gravel and cobble substrate from being removed from the beach. The existing beach beyond the dock features, shows evidence of larger gravel and cobble sized material armoring the upper surface with mixed sand and gravel sized material below. Armoring has helped prevent further down cutting below the bulkhead (Bethel, 2001).

The barge dock and historic fuel dock features trap sand as waves move sediment along the shoreline. This action "creates" a sandy beach in this area but deprives the remaining shore of sediment. Sieve analyses of beach sediment in the sheltered area between the barge dock and historic fuel dock shows that sand size material represents 25% to 58% of the beach and the remainder is gravel size material. This area was modified during construction of the seawall and sidewalk in 2003 and sand was added to this area.

4.0 CRITICAL AREA REVIEW

Critical areas of geotechnical concern are present within and adjacent to the study area. The critical areas include erosion, landslide, and seismic hazard areas. These critical area designations are discussed and defined in the King County Critical Areas Ordinance (CAO) that went into effect January 1, 2009. Because of the critical area designation, additional study may be required to meet environmental permitting requirements, to further assess impacts and mitigations. Erosion, landslide, and seismic hazard areas as defined by the King County CAO are mapped in Figure 8.The following is a brief description of the critical areas encountered within the project limits:

4.1 Erosion Hazards

Erosion is the displacement of soil, mud, and rock by the processes of water, wind, ice, and gravity. Erosion hazard areas are regulated by King County Code 21A.24.210. The King County CAO defines erosion hazard areas as those soils that may experience severe to very severe erosion. Steeper slopes generally have higher susceptibility to erosion since surface water will achieve high velocities and energy to erode and transport soil. All soils on slopes steeper than 40 percent have high potential for erosion. Soils on slopes inclined between 15 and 40 percent may have a medium or high erosion potential depending on the character of the soils.

Roadway Prism and Beach

Within the roadway prism and beach area, the runoff potential is considered low and the erosion hazard is considered slight due to the flatness of the topography and gravelly nature of the underlying in situ soils.

Bluff

The majority of bluff west of the roadway has slopes that are 40% or greater and would therefore be considered to have high erosion potential. In the southern bluff areas where till predominates, the erosion potential of these steep slopes would typically impact only the surficial weathered zone of the dense till. This weathered till zone would have rapid runoff and is susceptible to erosion from sheet or channel flow while the underlying till would be considered to have low erosion potential due to its high density and cohesive properties. Conversely, the outwash materials found adjacent the northern area of the project is less susceptible to sheet-flow erosion because of its high permeability. However, because of the lack of cohesion of the sands and gravels, the advanced outwash soils are highly prone to erosion and sediment transport during high-channel flows.

4.2 Landslide Hazard

Landslide hazard areas are defined as follows: (1) slopes with greater than 40 percent inclinations, (2) areas with slopes greater than 15 percent that are underlain by impermeable soils that include springs or groundwater seepage, (3) landslide areas that have moved during the Holocene epoch (last 10,000 years), (4) areas where rapid stream or wave erosion has created potentially unstable conditions, or (5) alluvial fans that are subject to inundation by debris or similar deposition of sediment.

In general, the steep bluff slopes are well vegetated with trees and underbrush. However, intermittent areas of unstable ground were observed based on visual evidence of scarps, tilted and bent trees, hummocky ground topography, and oversteepened slopes with thick soil cover. Based on current observations and road maintenance records, the stability issues associated with the bluff are chronic but generally surficial. Lidar imaging appears to support this finding based on the sharp bluff line shown in Figure 9.

4.3 Seismic Hazard

The CAO defines seismic hazard areas as those areas of King County subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. Seismically induced settlement or soil liquefaction can occur in areas underlain by cohesionless soils of low density, usually in conjunction with a shallow groundwater table. Potential landslide hazard areas are also at an increased risk of sliding during an earthquake.

An earthquake is a trembling motion caused by a sudden release of stress along a fault. Primary sources of earthquakes in the Puget Lowland include shallow, deep, and subduction-zone earthquakes as shown in Figure 10. Shallow earthquakes occur within the North American Plate at depths of 6 to 15 miles below ground. One of the largest strong shallow earthquakes that occurred in the Pacific Northwest was the North Cascade Earthquake of 1872, estimated at a magnitude of 7.4 (all magnitudes in this report are shown according to the Richter scale). Deep earthquakes are generated within the subducted Juan de Fuca plate and occur at depths of 24 to 36 miles below the ground and have estimated maximum magnitudes of 7.5. The three most recent larger earthquake events are the 7.1 magnitude Olympia Earthquake of 1949, and the 6.5 magnitude Seattle-Tacoma Earthquake of 1965, and the 6.8 magnitude Nisqually earthquake in 2001. The three earthquakes ranged from 32 to 36 miles below the ground surface and caused considerable damage to roadways and structures.

The Cascadia subduction zone refers to the zone of contact where the Juan de Fuca plate is being pushed underneath the North American plate at a rate of 1.5 to 2 inches a year. Although recent history in the Pacific Northwest lacks catastrophic events, there is evidence, both historical and geological, that a magnitude 9.0 earthquake occurred in 1700. This earthquake is believed to have created a huge tsunami that inundated the coastlines from southern British Columbia to Northern California. The frequency of these massive events is not well known but may be on the order of 300 to 400 years (Atwater and Hemphill-Haley 1996).

Dockton Road SW is located in an area of moderate historical seismicity. The Puget Sound Lowland experiences between 1,000 and 2,000 earthquakes yearly; the vast majority of these earthquakes, however, have magnitudes of less than 3.0 so they generally go unnoticed by people. Figure 11 shows recorded seismic events between 1965 and 2004 greater than 3.0 that have occurred within the general vicinity of the project.

Data used to create the map are provided in Appendix B. The information was obtained from the Northern California Earthquake Data Center (NCEDC) with data from the Pacific Northwest Seismograph Network (PNSN) branch of the Advanced National Seismic System (ANSS). The PNSN was started in 1969 to monitor regional earthquake activity in the Pacific Northwest. Seismic data obtained prior to the implementation of the PNSN is less accurate in terms of location, magnitude, and depth.

Liquefaction

Liquefaction occurs when loose, saturated granular soils such as fine sand and coarser silts lose their ability to support a load during a seismic event. The soils will actually flow like a fluid, resulting in ground settlement and deformation. Factors controlling the development of liquefaction include seismic intensity and duration, soil characteristics, in situ stress conditions, and the depth to the groundwater.

Based on the 1998 King County borings along the project corridor, the native soils underlying fill at Dockton Road SW generally consist of dense to very dense silty sands with intermittent silt and gravel. Therefore, structures located along the majority of the project alignment would have low liquefaction susceptibility. Alluvial deposits of loose fine sands were encountered in the northern project area near the mouth of Ellis Creek. Structures placed in this general area may be subject to liquefaction. However, given the wall heights will generally be 10 feet or less, the damage impact and risk of liquefaction would still be considered low to moderate.

Seismically Induced Landslides

Steep bluff areas are at an increased risk for seismically triggered landslides. However, based on site observations and road maintenance records, there is no evidence of past seismically triggered landslides within the project area boundaries.

Fault Zones

USGS has identified a significant number of active fault lines, or cracks, in the earth's crust in the central Puget Sound area. No faults have been identified within the boundaries of the project area. However, two major fault zones, Seattle and Tacoma, are located just to the north and south of the project area. Figure 12 shows USGS mapping of the Seattle and Tacoma faults zones.

The Seattle fault forms a 2.4 to 3.6 mile wide west to east trending zone of three or more south dipping reverse faults. The fault zone can be mapped in waterways across the Puget Lowland for at least 24 miles from Dyes Inlet to Lake Washington (http://earthquake.usgs.gov/regional/pacnw). The Tacoma Fault is a west to east trending fault that runs for approximately 30 miles across central Puget Sound. The area between the two faults has been uplifted with evidence suggesting the coastlines north of Tacoma Fault rose by as much as 13 feet about 1100 years ago (Sherrod 2003).

5.0 Geotechnical Alternative Assessment

Five alternatives are being evaluated to address the severely deteriorating condition of the Dockton seawall. These alternatives range from road removal and complete shoreline restoration to construction of a new roadway and seawall. Based on this preliminary analysis, all of the proposed alternatives would be feasible from a geotechnical perspective. A sixth alternative is a no action option that continues the status quo. From a geotechnical perspective, the biggest difference between the various alternatives would be the impact on bluff stability and potential methods to mitigate wave attack at the toe of the bluff. Additional major differences between the alternatives include potential impacts to cultural resources and impacts to intertidal and backshore habitat. However, considerations associated with these areas are addressed in cultural resource and environmental surveys prepared for this project and will therefore not be discussed further in this report. The following section identifies potential geotechnical considerations important to the evaluation of the various alternatives. Drawings of the various proposed alternatives are provided in Appendix C.

5.1 Alternative 1: Mixed Use Trail with Partially Expanded Beach

Alternative 1 closes the road to motorized traffic and constructs a six foot wide soft-surface trail and a 10 foot paved recreation trail. A wall will be constructed to provide lateral support of the trail and to protect the trail and bluff from erosion. The required height of the wall would be lessened under this alternative due to the reduced width of the proposed trail. The reduced height and increased setback from the current wall location may provide greater flexibility of wall option types and lessen tidal impacts on construction. If this alternative is selected, additional geotechnical analysis will be required to provide appropriate wall options and the associated design parameters to ensure the protection of the wall and trail from wave action.

5.2 Alternative 2: Paved Trail with Expanded Beach

Alternative 2 closes the road to motorized vehicles, removes the wall and roadway prism, and constructs a 4-foot wide trail. A rock revetment or retaining wall may be used to support the trail and to provide toe protection of the trail and wall. As in alternative 1, this would provide greater flexibility in embankment protection options and would likely make construction easier by lessening tidal influence on excavations. Due to reduced trail prism width and potential for future rise in sea levels, the trail and bluff may be more susceptible to wave attack. A more in depth geotechnical analysis would be required to determine the impacts of scour and sea level rise on rock revetment or retaining wall design if this alternative is selected.

5.3 Alternative 3: Natural Undisturbed Beach

Alternative 3 closes the road to motorized vehicles, removes the wall and the roadway, and attempts to restore the beach to its natural condition. Soft armoring vegetation and beach nourishment applications may be used to mitigate shore and bluff erosion. Though beach habitat would be improved, it is likely that even with shore protection mitigation, anticipated sea level rise and natural beach processes would lead to eventual wave attack of the bluff and accelerated bluff recession. If this alternative is selected, an in depth slope stability analysis would be required along with analysis of beach nourishment applications and soft armoring techniques.

5.4 Alternative 4: One-Way Road with 10-Foot Mixed Use Trail

Alternative 4 would convert Dockton Road SW to a one-way roadway with a 10 foot wide mixed use trail. This alternative would be similar to the current roadway in width and would provide ongoing toe protection of the bluff. Therefore, the geotechnical analysis required would be similar in scope to the analysis done for the 220 foot wall section constructed in 2003 and similar to alternatives 1 and 2..

5.5 Alternative 5: Two Lane Road with Cantilevered Sidewalk

Alternative 5 would be similar to the King County CIP project that was constructed in 2003. The 2003 project replaced 220 lineal feet of the existing timber pile and lagging wall with a drilled soldier pile wall with precast concrete facing. Construction cost for the 2003 wall was roughly $8,000 per lineal foot. Therefore, if this alternative is selected, a construction method and cost report as conducted by Berger/Abam Engineers Inc. for the 2003 project should be required. This report would evaluate several wall replacement options based on a number of factors such as cost, constructability, and environmental concerns. The construction method and cost report analysis should investigate and address construction issues associated with the 2003 project.

5.6 Alternative 6: Maintain Existing Seawall

Alternative 6 is considered the "no-build" option. Under this alternative, repair work would continue on the road on an emergency basis. No additional geotechnical analysis is anticipated under this alternative.

6.0 WALL REPLACEMENT OPTIONS

Berger/Abam Engineering Inc. provided King County DOT a detailed wall alternative evaluation construction and cost study in June 2001. The objective of this study was to determine feasible options for replacement of the deteriorating Dockton Road SW Seawall. In addition, the study determined possible construction methods and cost associated with the various wall alternatives along with addressing potential environmental and permitting issues. After consideration of site conditions, five wall options were chosen for evaluation. The options included both gravity and deep pile alternatives. In the end, the drilled soldier pile wall with concrete fascia was picked as the preferred alternative. For additional detail, the original Berger/Abam report should be reviewed.

Due to the cost associated with construction of the 220 foot long seawall in 2003, it may be advantageous to re-examine assumptions made by Berger/Abam when considering future wall replacement or slope protection options. Key construction and design personal experienced with site issues in 2003, as well as the original wall contractor, should be consulted for the new evaluation early in the design process.

7.0 LIMITATIONS

This preliminary phase 1 geotechnical report is provided to aid in alternative evaluation and selection. Once the alternative selection is made, additional geotechnical investigation and analyses will be needed for design of specific structures such as pavements, retaining walls and culverts.

We trust this report meets your current request. Please call Doug Walters at 296-7708, or Alan Corwin at 296-7711, if you have any questions, concerns, or if we may be of further assistance.

Sincerely,
King County Materials Laboratory

Alan D. Corwin, P.E.
King County Materials Engineer

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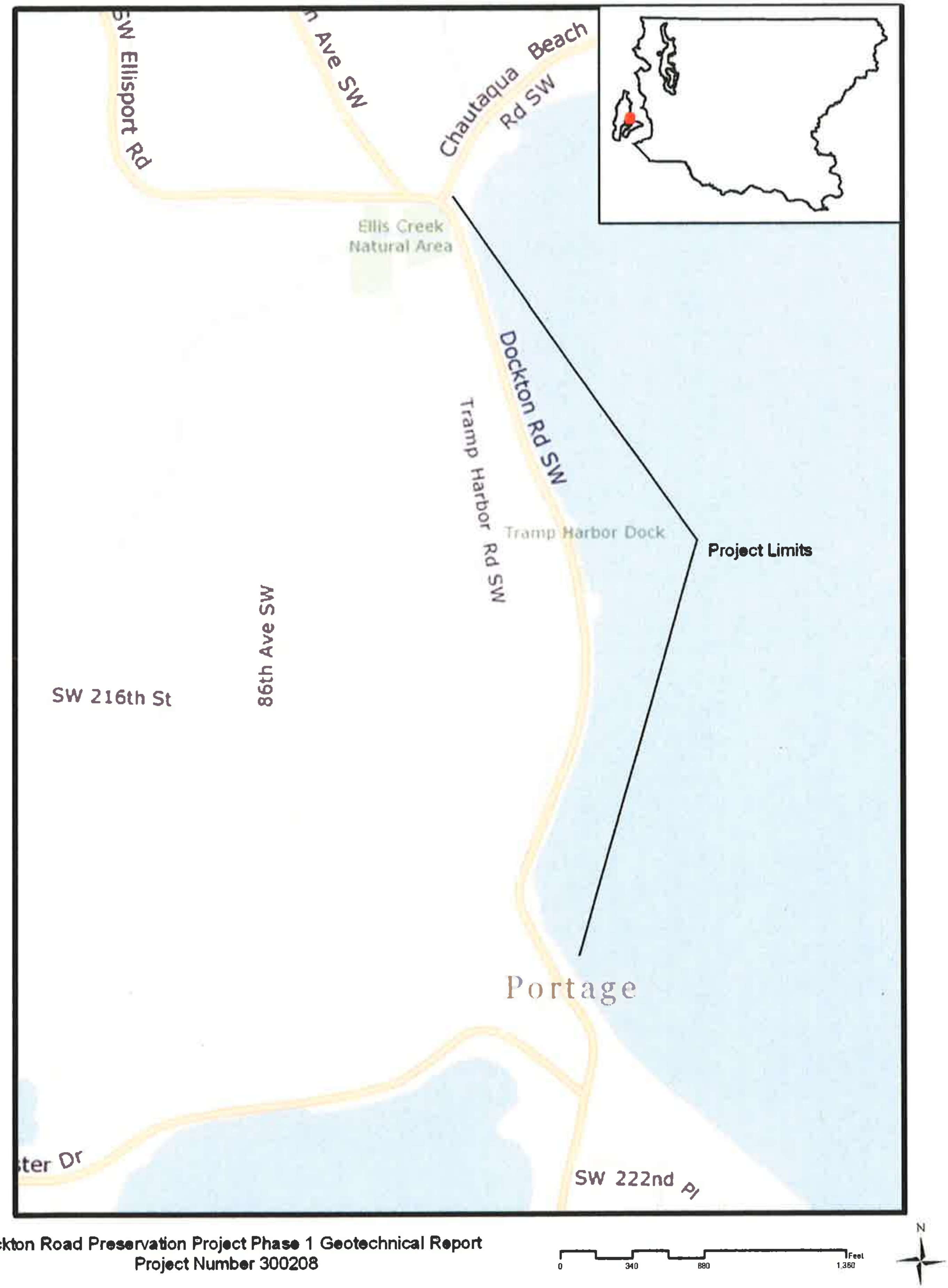
Washington State Department of Ecology Well Log Viewer Database
http://apps.ecy.wa.gov/welllog/

Figure 1: Vicinity Map



Dockton Road Preservation Project Phase 1 Geotechnical Report
Project Number 300208

Figure 2: Surficial Geology

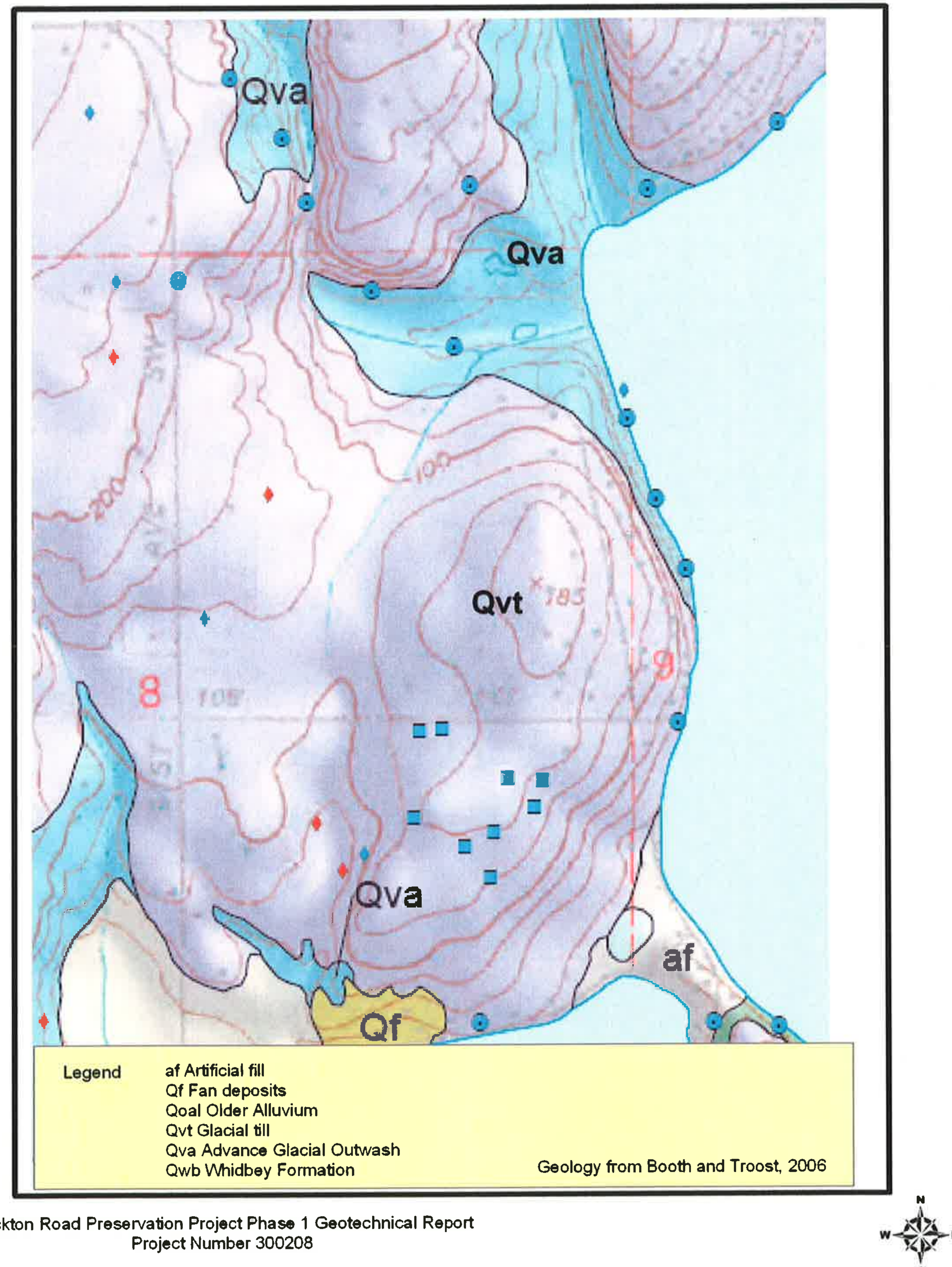
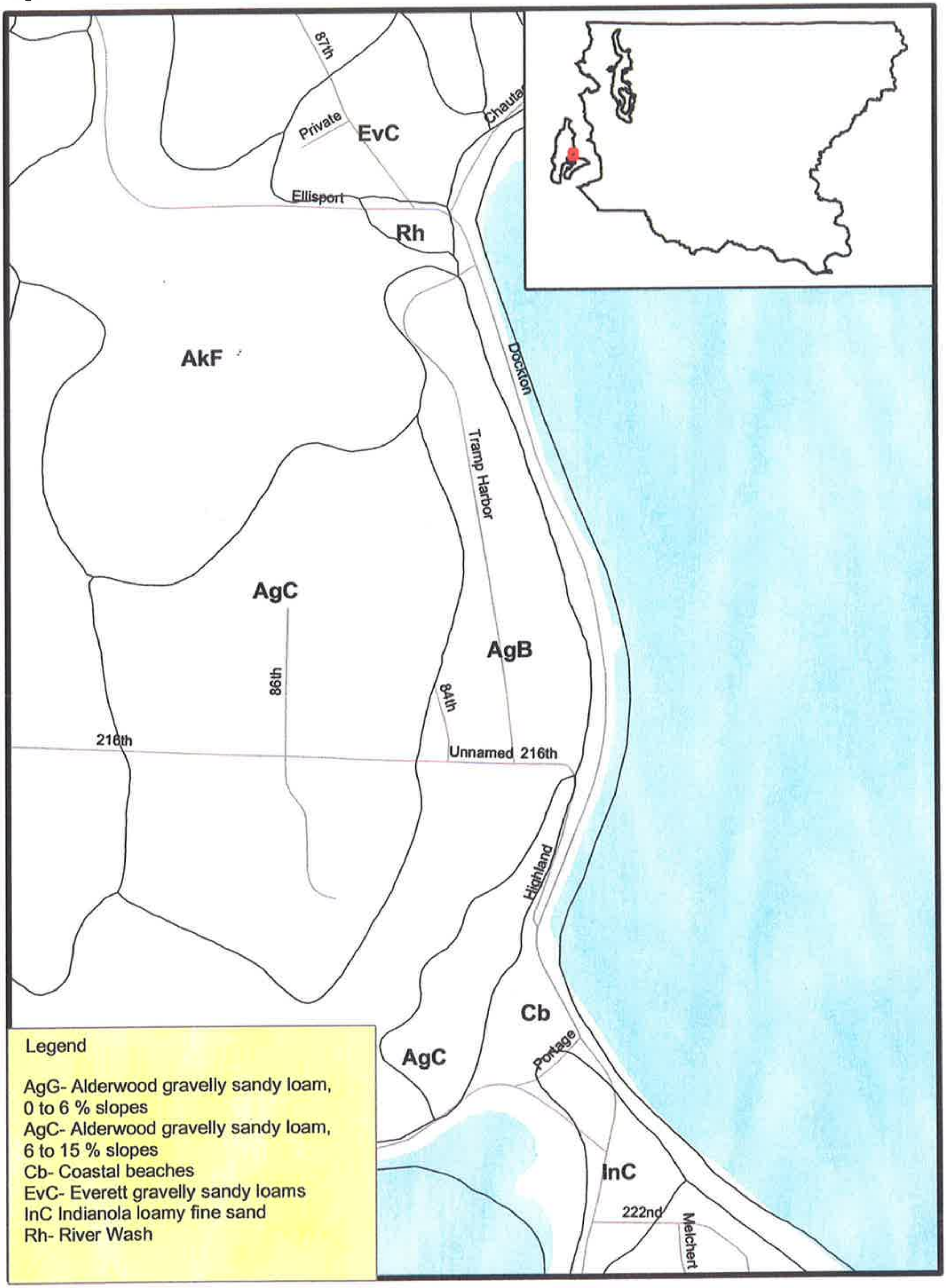


Figure 3: USDA Soil Survey Map



0 337.5 675 1,350 Feet

N W E S

Figure 4: Borings, Hand Auger Holes and 2009 Landslide Locations

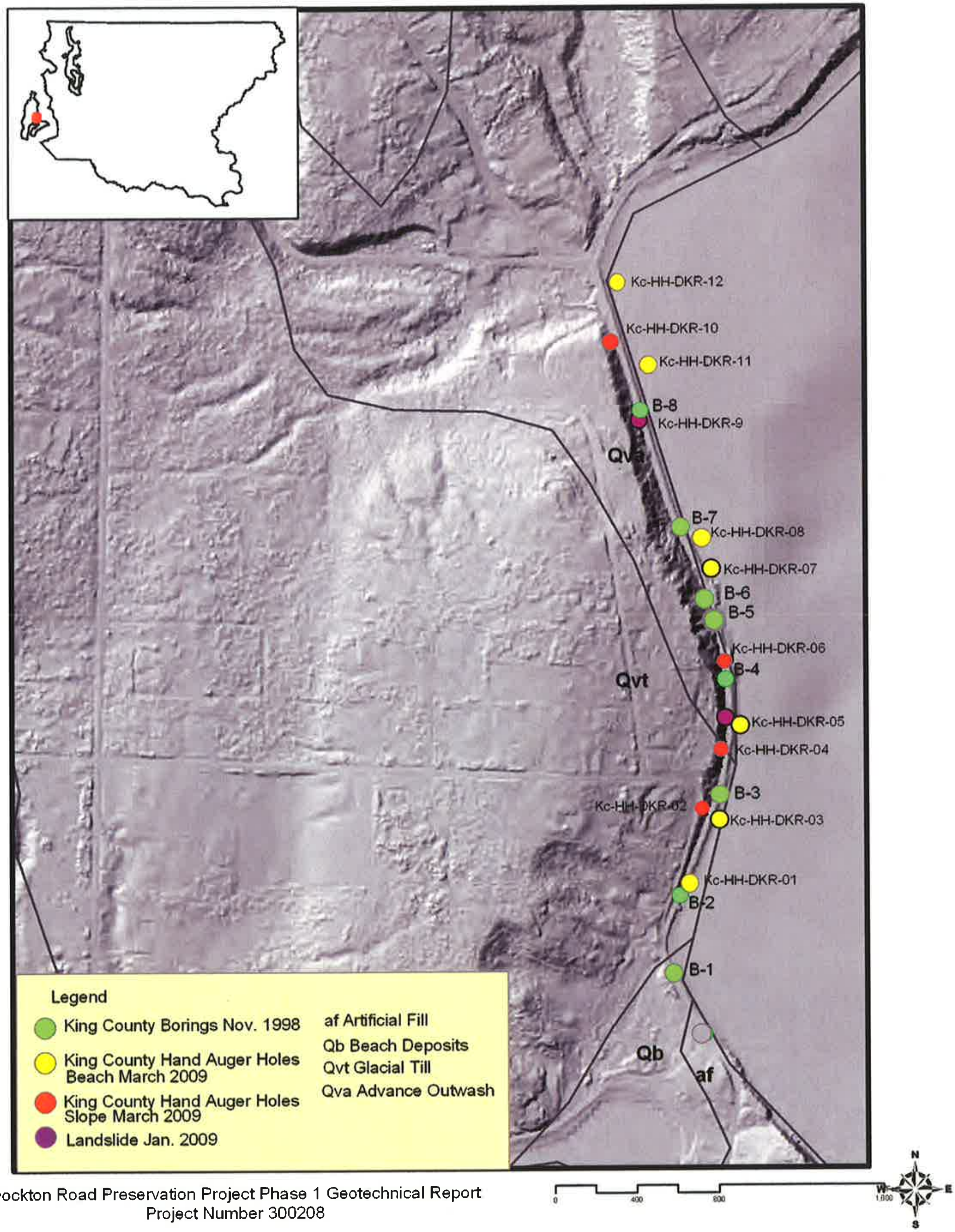


Figure 5: Conceptual Geologic Model

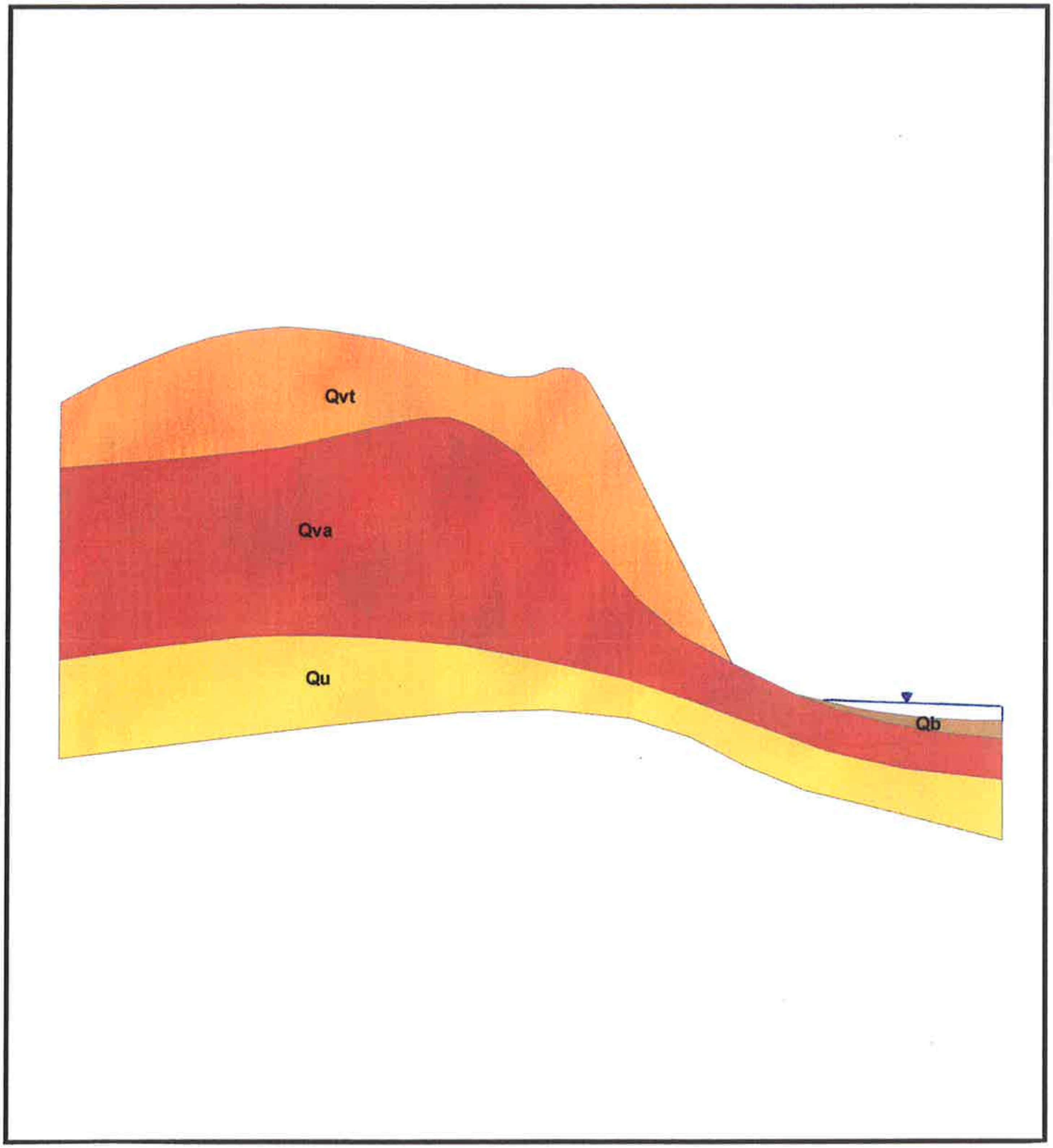


Figure 6: Drain lines from parcels extending down the slope to Dockton Road.

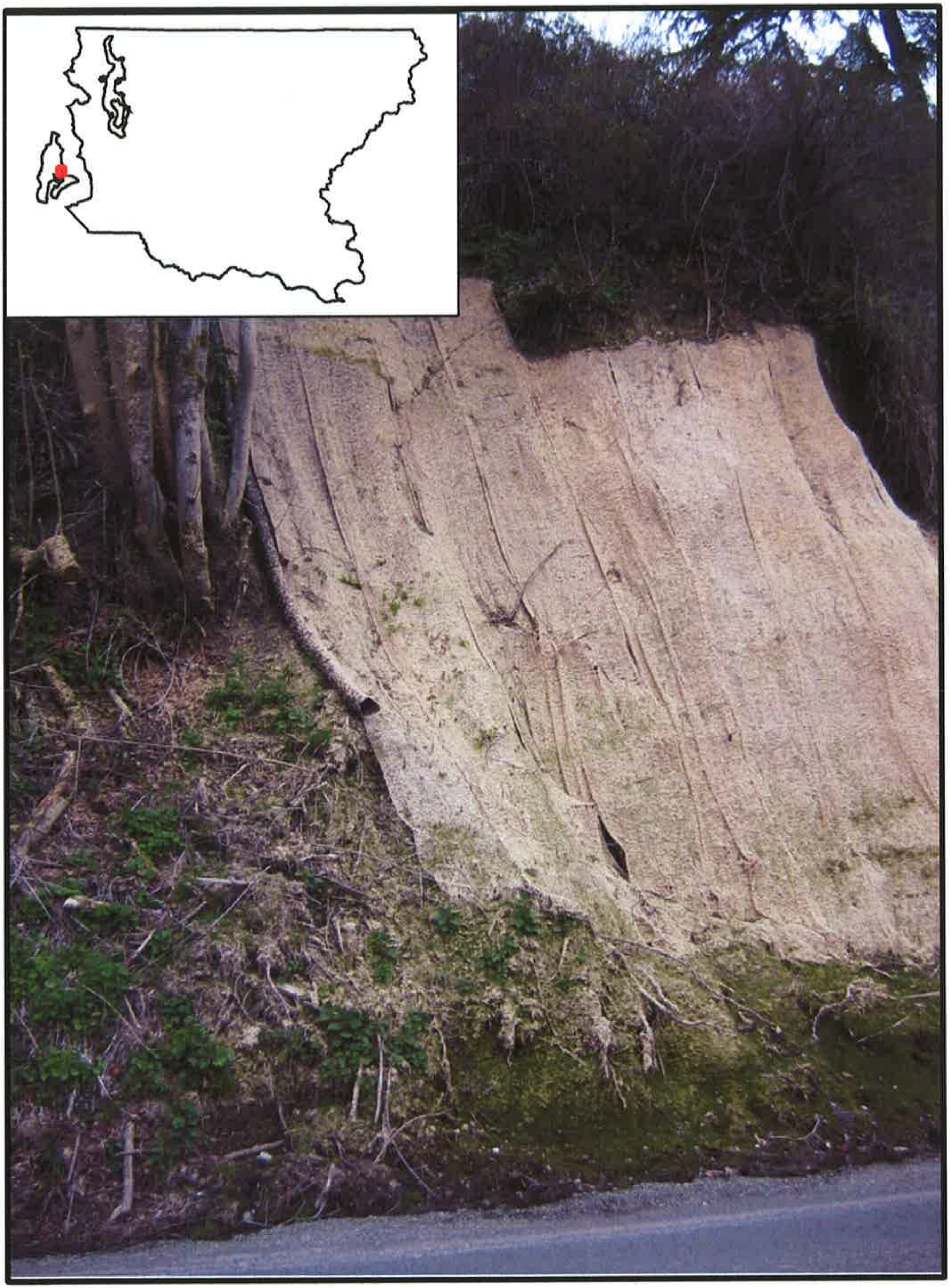


Figure 7: Shallow landslide in weathered sediments above Dockton Road.

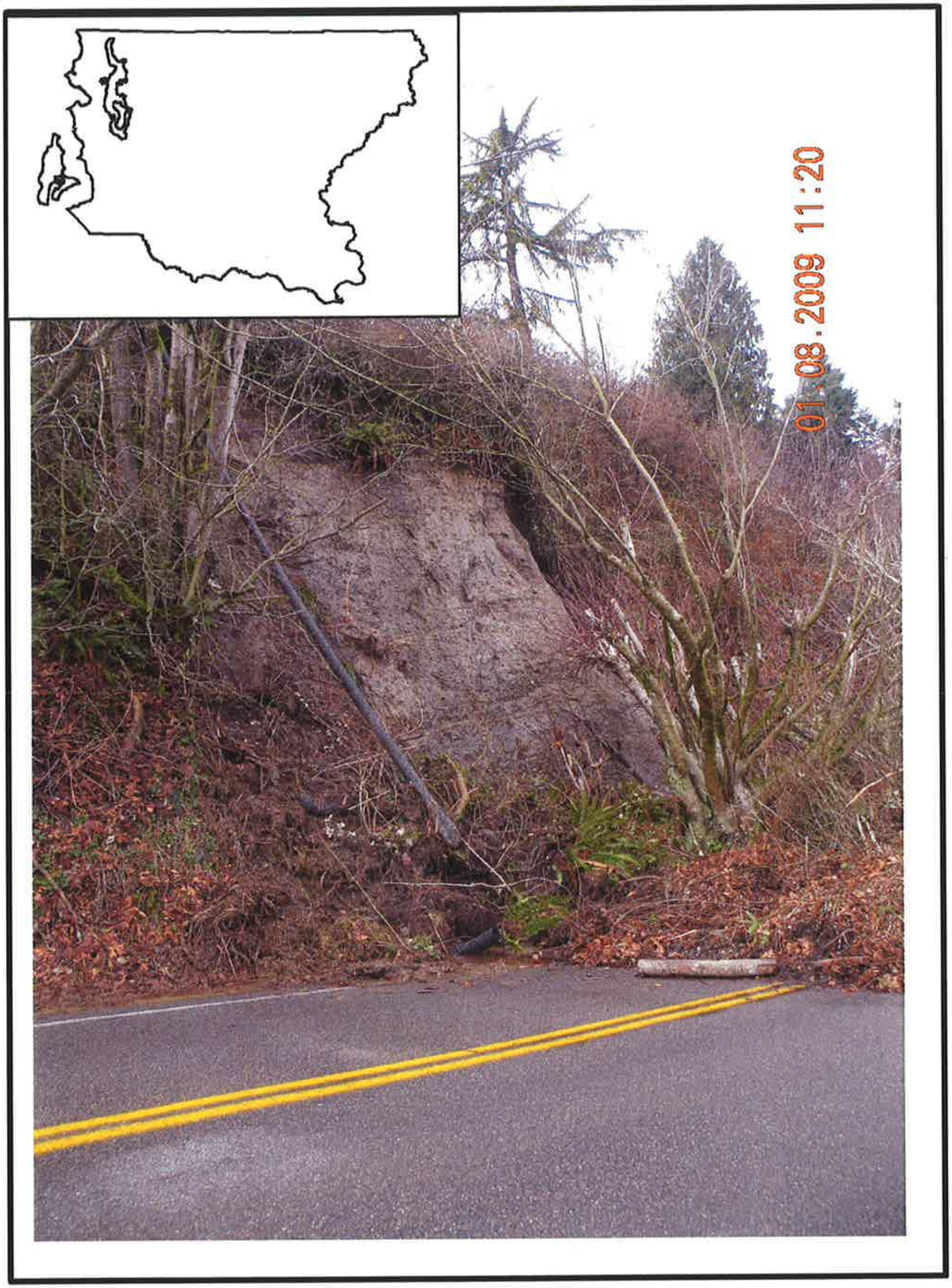
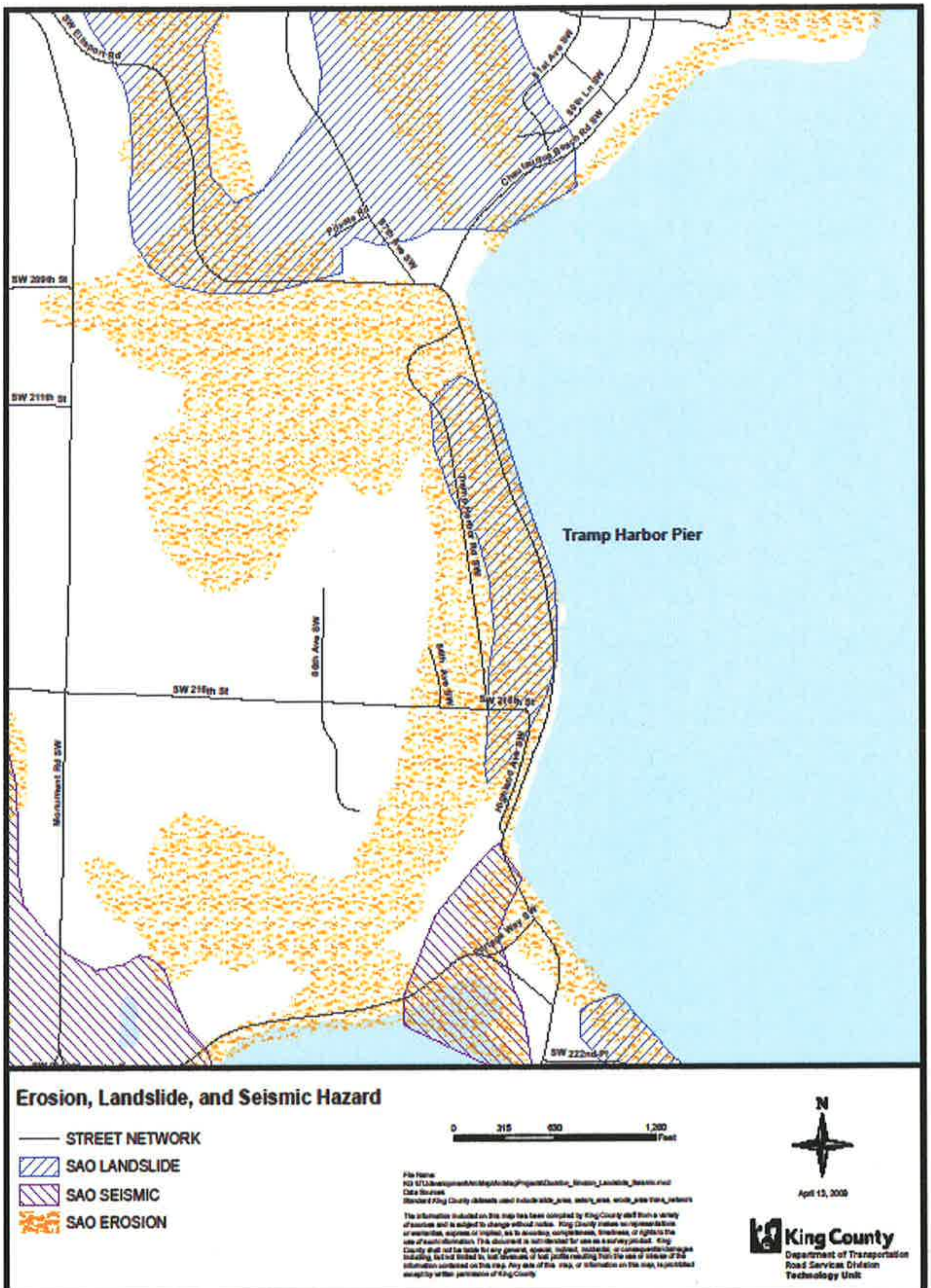


Figure 8: Hazards Map



Dockton Road Preservation Project Phase 1 Geotechnical Report
Project Number 300208

Figure 9: Lidar Image

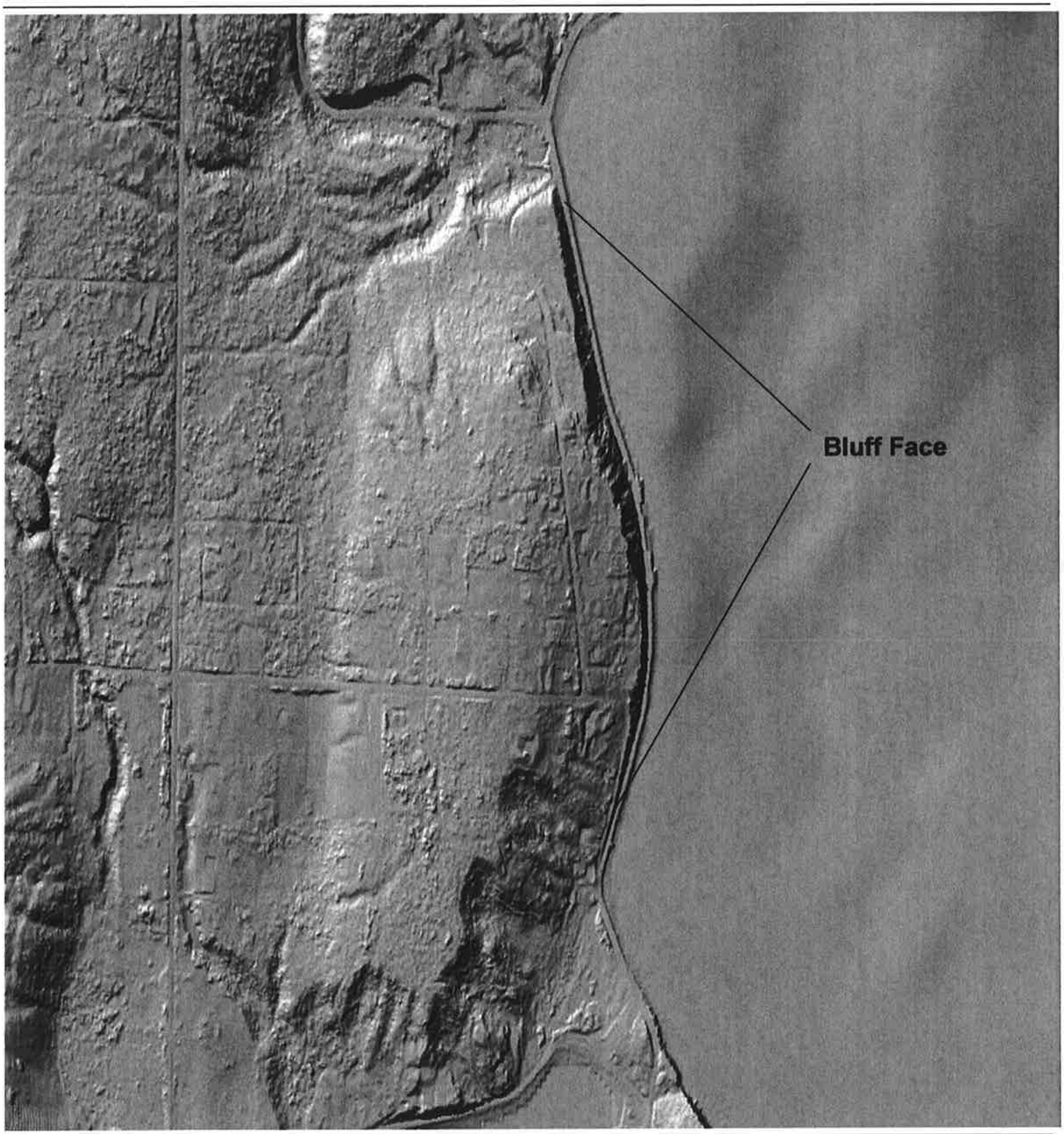
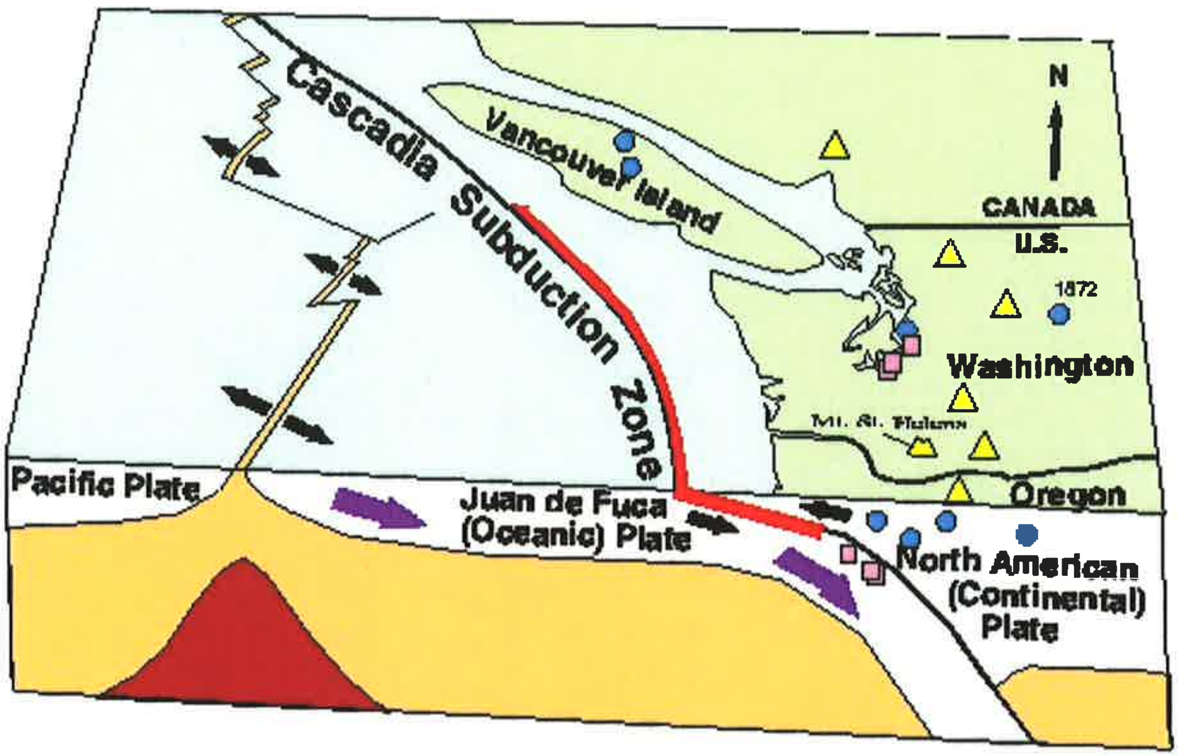


Figure 10: Pacific Northwest Tectonic Setting



Deep Earthquakes (40 miles below the Earth's surface) are within the subducting oceanic plate as it bends beneath the continental plate. The largest deep Northwest earthquakes known were in 1949 (M 7.1), 1965 (M 6.5), and 2001 (M 6.8).

Shallow earthquakes (less than 15 miles deep) are caused by faults in the North American Continent. The Seattle fault produced a shallow magnitude 7+ earthquake 1,100 years ago. Other magnitude 7+ earthquakes occurred in 1872, 1918, and 1946.

Subduction Earthquakes are huge quakes that result when the boundary between the oceanic and continental plates ruptures. In 1700, the most recent Cascadia Subduction Zone earthquake sent a tsunami as far as Japan.

Mt. St. Helens/Other Cascade Volcanoes

Figure 11: Recorded Seismic Events

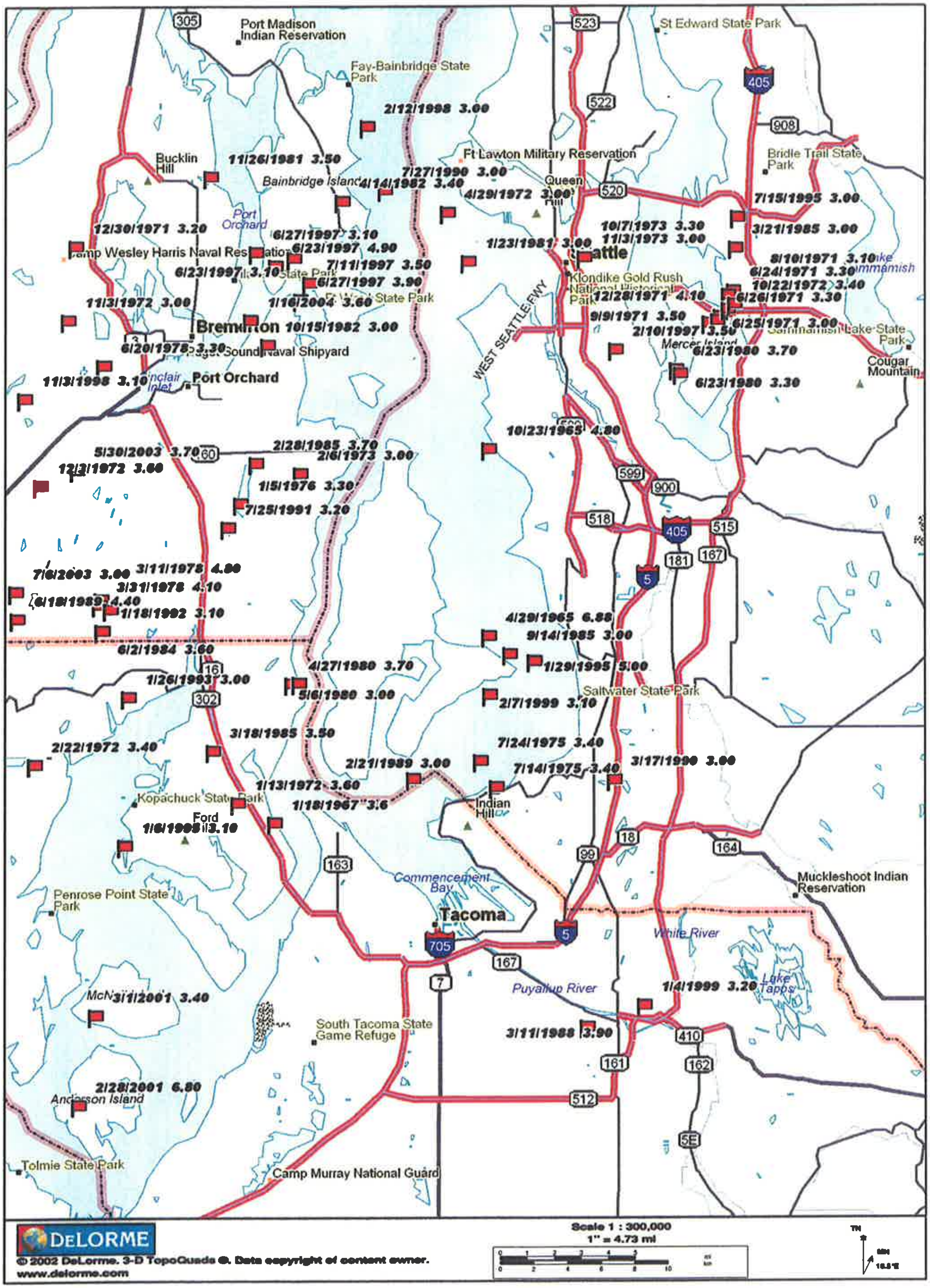
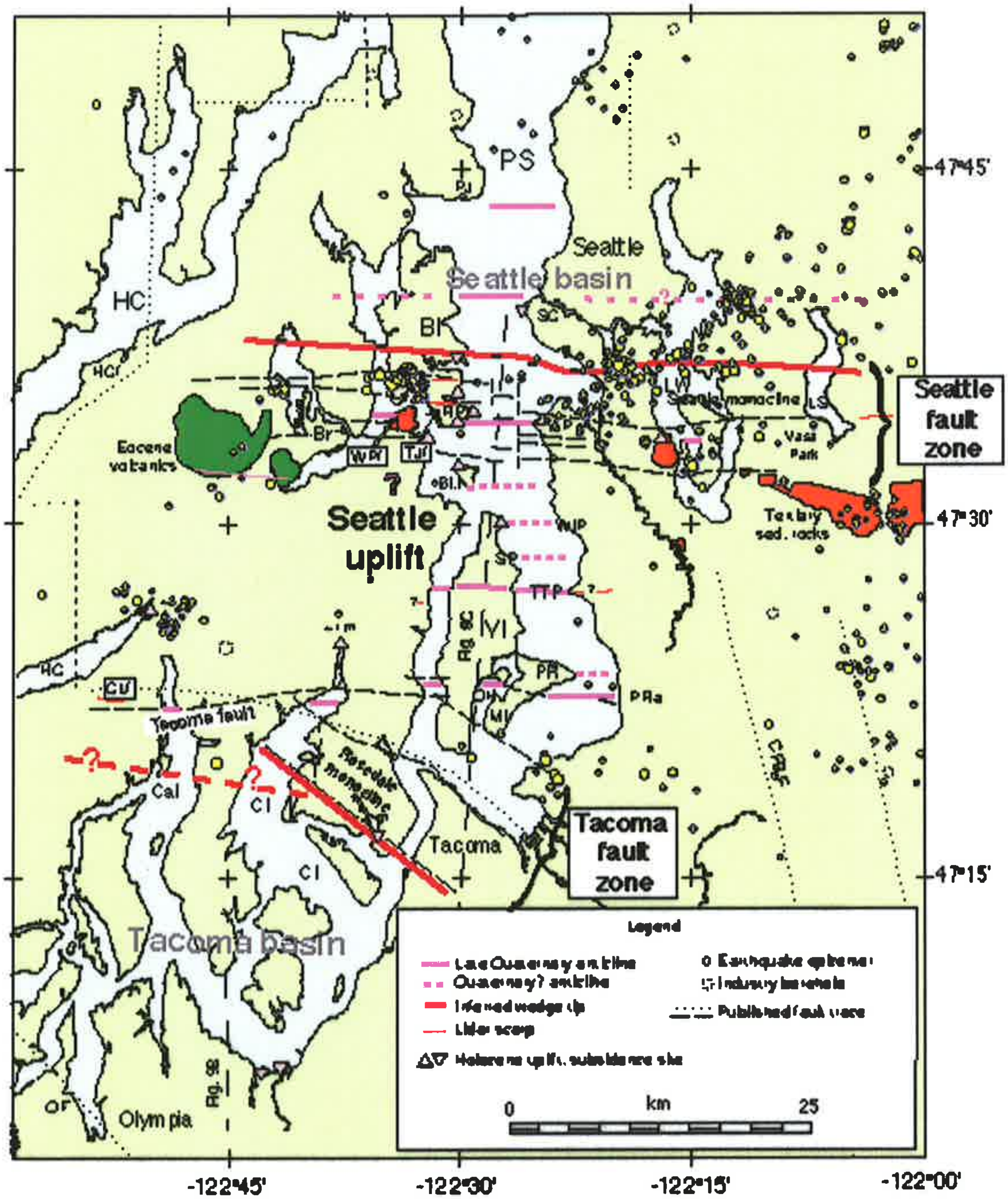


Figure 12: Seattle and Tacoma Fault Zones



Appendix A

Existing Subsurface Logs

LOG OF BORING
BORING 1

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 2+84 East 6 Ft. Left of CL.**
DRILL METHOD: **Six inch Odex**
DRILLER: **R and R drilling**
DEPTH TO WATER: **6'**
Caving:

DATE: **November 3, 1998**
START: **0900**
FINISH: **1440**
LOGGER: **D. Armstrong**
DATE CHECKED: **11/3/98**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
100 / 0			Asphalt Pavement.			
	1,2,4	SP-SM	Crushed Surfacing Top Course. Brown poorly graded sand with silt and gravel, moist, medium dense.			
95 / 5	4,9,10	GP	Brown poorly graded gravel with sand, moist to wet, medium dense. Scattered wood debris at six feet and shell fragments at seven feet.	4.8		
	2,5,9	PT	Peat, wet, soft. Sampler shoe blocked with a rock. Blows may be overstated.	107.1		
90 / 10		SP	Brown, poorly graded sand, wet, medium dense.	19.1		
85 / 15	4,5,10; 14,13,30; 32,49,44	SM	Gray and brown, silty sand, wet, medium dense to very dense. Strong Hydrogen Sulfide odor. Less gravel.	17.2	29.4	
80 / 20	19,28,29	SP	Gray brown poorly graded sand, wet, very dense. Gravel lense felt during drilling.			
75 / 25	17,26,38	SM	Gray brown silty sand, wet, very dense.	14.5	20.9	
70 / 30	7,15,23	SP-SM	Brown poorly graded sand with silt, wet, dense.	22.5	7.5	
65 / 35	6,7,29	SM	Gray silty sand, wet, dense. Trace of subrounded gravel.			

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-1**

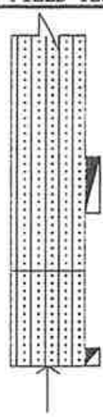
KING COUNTY MATERIALS LABORATORY

LOG OF BORING

BORING 1

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 2+84 East 6 Ft. Left of CL.**
DRILL METHOD: **Six inch Odex**
DRILLER: **R and R drilling**
DEPTH TO WATER: **6'** Caving:

DATE: **November 3, 1998**
START: **0900**
FINISH: **1440**
LOGGER: **D. Armstrong**
DATE CHECKED: **11/3/98**



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Decrease in gravel content			
60 / 40	3,11,14			19.3	28.5	
		SM	Gray silty sand, wet, very dense.			
55 / 45	50\6"					
50 / 50						
45 / 55						
40 / 60						
35 / 65						
30 / 70						

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-1**

KING COUNTY MATERIALS LABORATORY

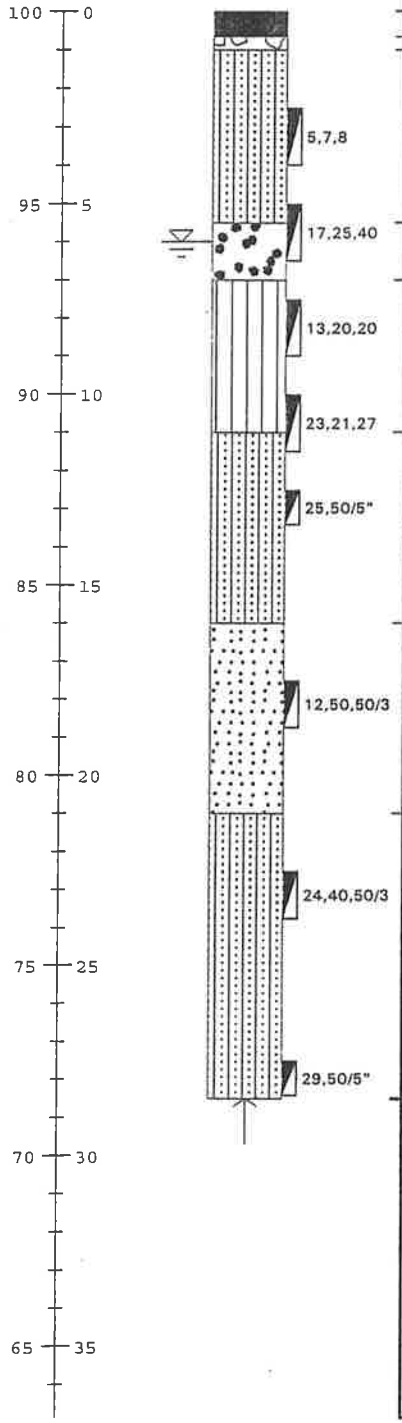
LOG OF BORING

BORING 2

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 0+53 North 6 Ft. Right of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling**
DEPTH TO WATER: **6'**
Caving:

DATE: **November 4, 1998**
START: **0830**
FINISH: **1000**
LOGGER: **D. Armstrong**
DATE CHECKED: **Nov. 4, 1998**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
	Asphalt Pavement.			
SM	Crushed Surfacing Top Course.	10.6	27.6	
	Brown silty sand, moist, medium dense, (fill). Trace subrounded gravel.			
GP	Brown poorly graded gravel with sand, moist, very dense. (Standard Penetration Test blows may be over stated)			
ML	Gray brown sandy silt, wet, dense. Scattered iron stains	21.4	52.1	Material contact found in sampler.
		16.4	26.1	
SM	Gray brown silty sand, wet, dense. Trace subrounded gravel. (Standard Penetration Test blows may be overstated. Sampler shoe contained a rock).			Six inch water bearing sand zone at 12.7 feet.
SP	Dark brown poorly graded sand with gravel, wet, very dense. (Standard Penetration test blows may be over stated. Sampler shoe contained a rock).			
SM	Gray silty sand, wet, very dense. Trace subrounded gravel.	14.8	36.4	

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-2**

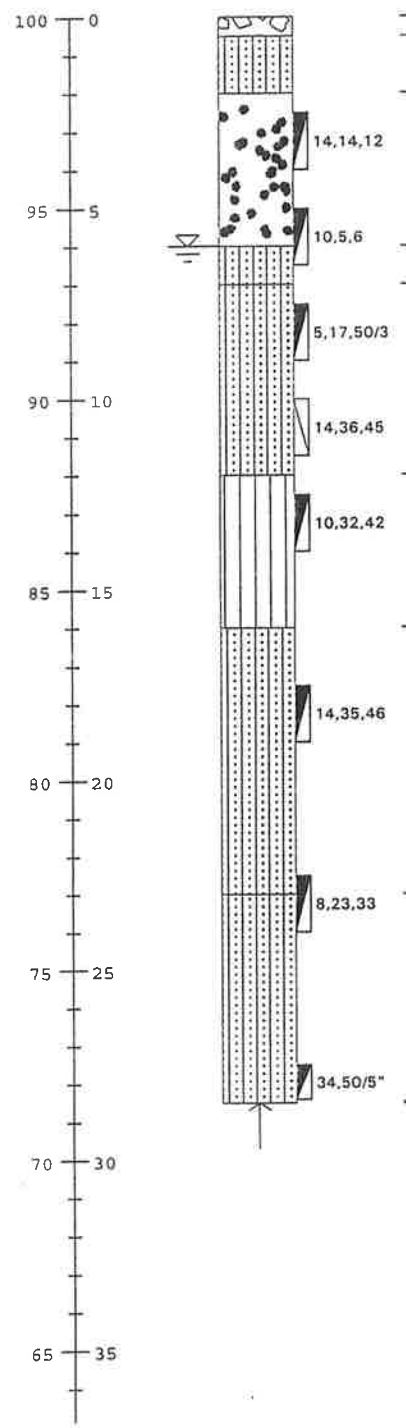
KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 3

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 6+33 North 12 Ft. Right of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling** x4
DEPTH TO WATER: **6'** 349 Caving:

DATE: **November 4, 1998**
START: **1010**
FINISH: **1150**
LOGGER: **D. Armstrong**
DATE CHECKED: **Nov. 4, 1998**

ELEVATION/DEPTH | SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
SM	Crushed Surfacing Top Course.			
	Brown silty sand with gravel and cobbles, moist, medium dense (fill).			
GP	Brown poorly graded gravel with sand, moist, medium dense (fill).	26.5	45.5	
SM	Gray brown silty sand, moist, medium dense.			Material change found in the sampler.
SM	Dark brown silty sand with gravel and cobbles, moist to wet, very dense. (Standard Penetration Test blows may be overstated. A rock was wedged in the sampler shoe. rock wedged in sampler tip.			
ML	Gray brown sandy silt, wet, very dense. Laminated. Laminations two millimeters thick.	20.8	65.0	
SM	Gray silty sand with gravel, wet, very dense.			
SM	Brown silty sand with gravel, wet, very dense. (till like texture).			

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-3**

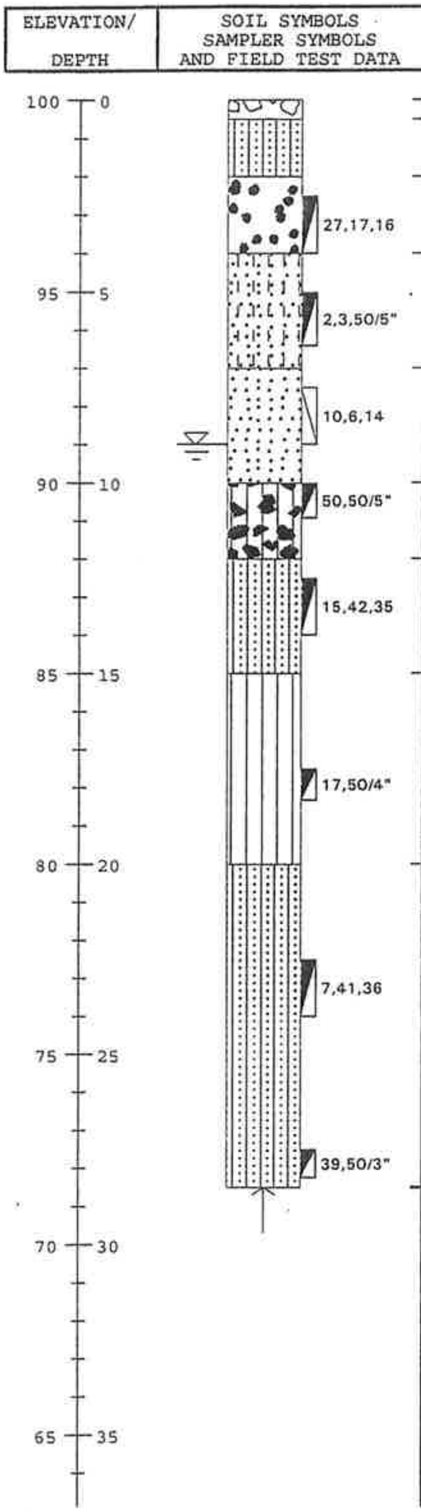
KING COUNTY MATERIALS LABORATORY

LOG OF BORING

BORING 4

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 11+29 North 15 Ft. Right of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling**
DEPTH TO WATER: **9'**
Caving:

DATE: **November 4, 1998**
START: **1245**
FINISH: **1415**
LOGGER: **D. Walters**
DATE CHECKED: **Nov. 4, 1998**



USCS	Description	Moist (%)	-200 (%)	Remarks
SM	Crushed Surfacing Top Course (shoulder gravel).			
GP	Brown silty sand with gravel, moist, dense (fill).			
SP-SM	Gray, poorly graded gravel with sand, moist, dense (fill).	10.3	10.2	
SP	Brown, poorly graded sand with silt and gravel wet, loose. Sampler pounded into a creosote treated log at 6 feet below the surface.			
GM	Brown poorly graded sand, wet, medium dense.			
SM	Gray silty gravel with sand, wet, very dense.	19.8	39.6	
	Gray brown silty sand, wet, very dense.			
ML	Gray brown silt, moist, very dense.			
	Trace of iron staining.	21.8	91.1	
SM	Gray brown silty sand with subrounded gravel, wet, very dense.			

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-4**

KING COUNTY MATERIALS LABORATORY

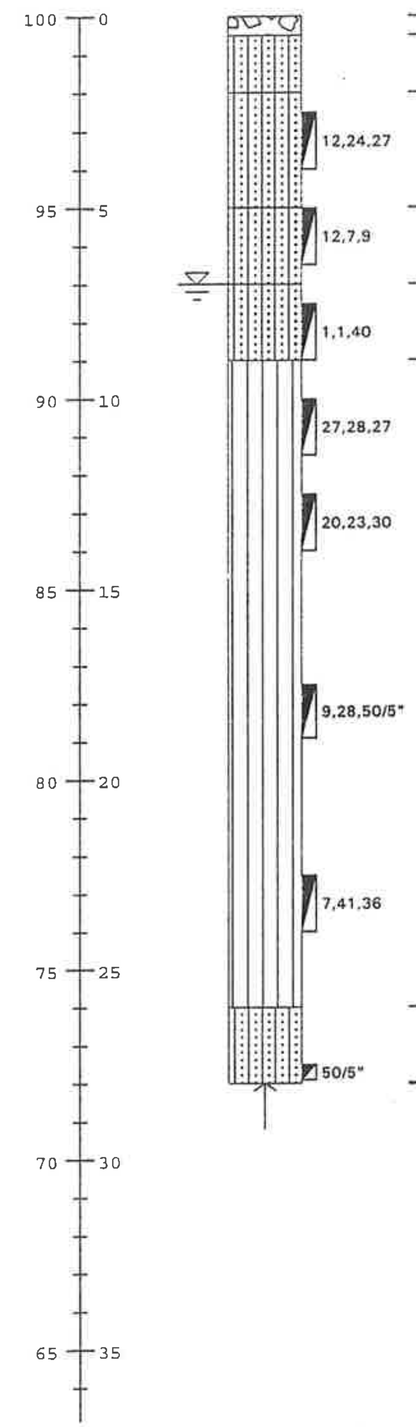
LOG OF BORING

BORING 5

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 14+20 North 13 Ft. Right of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling**
DEPTH TO WATER: **7'** Caving:

DATE: **November 4, 1998**
START: **1425**
FINISH: **1620**
LOGGER: **D. Walters**
DATE CHECKED: **Nov. 4, 1998**

ELEVATION/ DEPTH | SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
SM	Crushed Surfacing Top Course (shoulder gravel).			
SM	Brown silty sand with gravel, moist, medium dense (fill).			
SM	Gray brown silty sand with gravel, moist, dense (fill). Standard Penetration Test blows may be overstated. A rock was wedged in the shoe of the sampler.	15.9	25.0	
SM	Light gray silty sand, moist, medium dense.			
ML	Dark gray silty sand, wet, medium dense. Standard Penetration Test blows may be overstated. A rock was wedged in the shoe of the sampler.	28.6	65.5	
	Dark gray sandy silt, moist to wet, very dense.			
SM	Dark gray silty sand, wet, very dense.			

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-5**

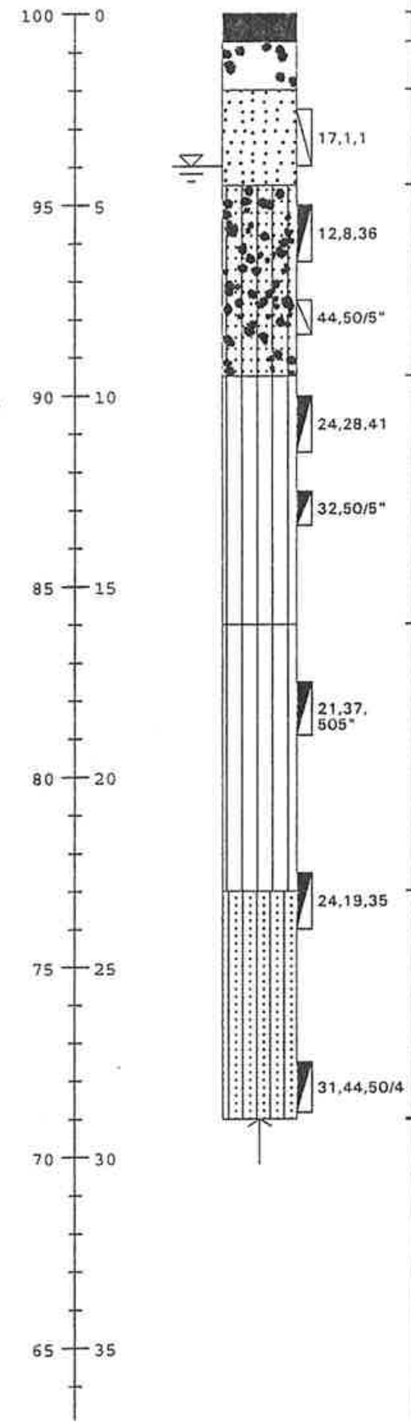
LOG OF BORING

BORING 6

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 14+32 North 7 Ft. Left of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling**
DEPTH TO WATER: **4'** Caving:

DATE: **November 5, 1998**
START: **8:15**
FINISH: **9:45**
LOGGER: **D. Walters**
DATE CHECKED: **Nov. 5, 1998**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Asphaltic Concrete Pavement.			
		GP	Brown poorly graded gravel with sand and silt, moist, medium dense (fill).			
	17,1,1	SP	Gray poorly graded sand, moist, loose (fill).			
	12,8,36; 44,50/5"	GP-GM	Gray poorly graded gravel with silt and sand, moist to wet, dense. Standard Penetration Test blows may be overstated. A rock wedged in the shoe of the sampler.	9.7	8.4	
	24,28,41; 32,50/5"	ML	Gray silt with sand, moist to wet, very dense.	26.2	73	
	21,37, 505"	ML	Gray sandy silt, moist, very dense. Trace of laminations.	27.0	27.4	
	24,19,35; 31,44,50/4	SM	Gray silty sand, wet, very dense.			



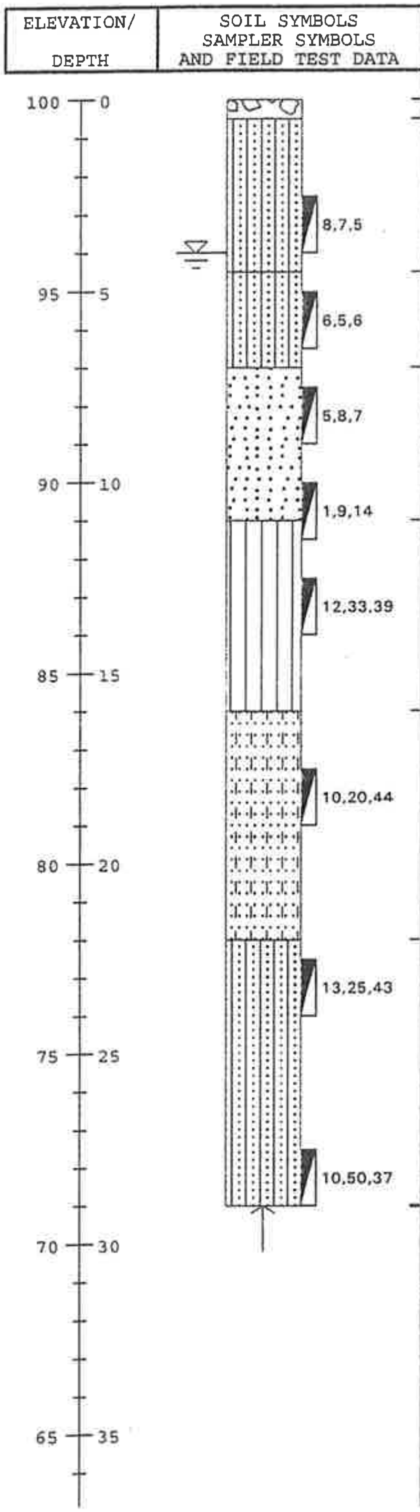
Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-6**

LOG OF BORING
BORING 7

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 18+24 North 10 Ft. Right of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling**
DEPTH TO WATER: **4'**
Caving:

DATE: **November 5, 1998**
START: **10:00**
FINISH: **11:10**
LOGGER: **D. Walters**
DATE CHECKED: **Nov. 5, 1998**



USCS	Description	Moist (%)	-200 (%)	Remarks
SM	Crushed Surfacing Top Course (Shoulder Gravel).			
	Gray and brown, silty sand, moist, medium dense (fill).			
SM	Brown silty sand, moist to wet, medium dense.	25.0	39.6	
SP	Brown poorly graded sand, wet, medium dense.			
ML	Gray sandy silt, moist to wet, medium dense to very dense.	27.8	92.7	
SW-SM	Gray well graded sand with silt and gravel, wet, very dense.	11.5	11.0	
SM	Gray silty sand, wet, very dense.			

Boring locations based on Stationing marked on the shoulder of the road.

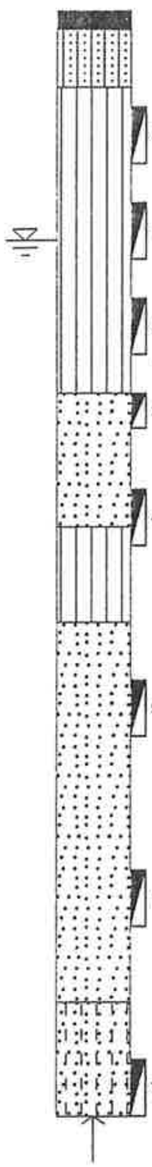
PLATE NUMBER **A-7**

KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 8

PROJECT: **Dockton Road Seawall**
BORING LOCATION: **Sta. 25+18 North 5 Ft. Right of CL.**
DRILL METHOD: **4 inch ID Hollow Stem Auger**
DRILLER: **R and R drilling**
DEPTH TO WATER: **6'**
Caving:

DATE: **November 5, 1998**
START: **11:15**
FINISH: **12:45**
LOGGER: **D. Walters**
DATE CHECKED: **Nov. 5, 1998**



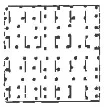
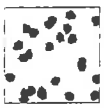
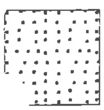
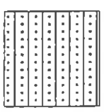
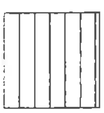
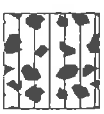
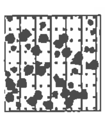
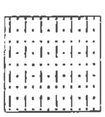
ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
100 / 0		SM	Asphaltic Concrete Pavement. Brown silty sand, moist, medium dense (fill).			
	8,15,15	ML	Gray silt, trace shell fragments, trace iron staining, moist, medium dense, Trace iron staining.	29.0	98.2	
95 / 5	14,13,17					
	2,3,8					
90 / 10	38,50/5"	SP	Gray poorly graded sand, wet, very dense.			
	4,19,40					
		ML	Gray silt, moist, hard, laminated.	28.3	98.8	
85 / 15		SP	Gray poorly graded sand, wet, very dense.			
	9,18,26					
80 / 20						
	11,29,42					
75 / 25		SP-SM	Gray poorly graded sand with silt, wet, very dense.	4.6	10.8	
	7,21,29					
70 / 30						
65 / 35						

Boring locations based on Stationing marked on the shoulder of the road.

PLATE NUMBER **A-8**

KING COUNTY MATERIALS LABORATORY

KEY TO SYMBOLS

Symbol	Description
Strata symbols	
	Paving
	Crushed Surfacing
	Poorly graded sand with silt
	Poorly graded gravel
	Peat
	Poorly graded sand
	Silty sand
	Silt
	Silty gravel
	Poorly graded gravel with silt
	Well graded sand with silt
Misc. Symbols	
	Water table during drilling

Symbol	Description
	Boring continues
	End of Boring
Soil Samplers	
	Standard penetration test
	No recovery

KEY TO SYMBOLS

Notes:

1. Exploratory borings were drilled from November 3 through November 5, 1998 using a truck mounted 4-inch ID continuous flight Hollow Stem Auger.

2. Free water was encountered at the time of drilling.

3. Boring locations were taped from stationing along the side of the road. Boring elevations were assumed to be 100 feet for drafting purposes.

4. Results of test conducted on samples recovered are reported on the logs.

5. These logs are subject to the limitations, conclusions, and recommendations in this report.

King County
Dept. of Transportation
Materials Laboratory

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Test Boring Log

155 Monroe Avenue NE, Bldg D
Renton, WA 98056-4199
Phone 206/296-7709
Fax 206/296-0179

Project: Dockton	Elev.:	Job No.:	Boring KC-HA-DKR-01
		Drilling Method: shovel and posthole	
Drilling Contr.:		Sampling Method:	
Drilling Oper.: Doug W.		Hammer Wt.: Drop:	Sheet
Start Time: 11 10 Stop Time:		Date: 3-13-09 By: J. Chiney	1 of

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition Beach 1-5" size
							3-4" Gravel on beach surface armor
					1		2" Sand w/ shell fragments
						▽	remainder gravel w/ sand rounded to sub-rounded
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________.

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Test Boring Log

155 Monroe Avenue NE, Bldg D
Renton, WA 98056-4199
Phone 206/296-7709
Fax 206/296-0179

Project: Deckton Rd	Elev.:	Job No.:		Boring KC-HH-DKR-02
		Drilling Method: Hand auger		
Drilling Contr.:		Sampling Method: Hand au.		
Drilling Oper.: D Walters J. Turner		Hammer Wt.:	Drop:	Sheet
Start Time: 10:13	Stop Time: 11 00	Date: 3-13 2009	By: J. Turner	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition: singe leaf litter, Nettle
					1		Top soil brn Dry to Moist organics roots, worms
					2		Iron staining silty sand, low plasticity Tan, 1/2+1" rounded gravel
					3		wet. Gravel & grey tan silty fine med sand, proper Gravel 1/4-1"
			29 30+	1 3/4" 3" 5 1/2"	4		Low plasticity, iron staining, rootlets, ⅛-⅛ sub-rd. Poorly graded sand, w/ gravel 1/4-1/2 inch charcoal, wood Dryer
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at 3.4/25 feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with native mat

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Test Boring Log

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Fax 206/296-0179

Project: Dockton	Elev.:	Job No.:	Boring 3
		Drilling Method: posthole & bar	
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 11 30 Stop Time:		Date: 8-13-09 By: J Tanley	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code
					1	▽13"
					2	
					3	
					4	
					5	
					6	
					7	
					8	
					9	
					0	
					1	
					2	
					3	
					4	
					5	
					6	
					7	
					8	
					9	
					0	

Surface Condition
Beach cobble to rip rap rubble distributed on surface
gravel surface with 2-3" of predominantly
sand w/ gravel & shell then predominantly
gravel to 14". end of hole
rounded to subrounded.

Boring terminated at _______ feet below existing grade. Groundwater encountered at (NO groundwater encountered) _______ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) _______. Lower _______ feet slotted. Boring backfilled with _______

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Test Boring Log

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Fax 206/296-0179

Project: Docketon	Elev.:	Job No.:		Boring KC-HH DKE-4
		Drilling Method:		
Drilling Contr.:		Sampling Method:		
Drilling Oper.:		Hammer Wt.:	Drop:	Sheet
Start Time: 12:11 pm	Stop Time:	Date: 3-13-09	By: J. Turney	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition: Blackberry, nettle leaf litter
							Top soil, brn
					1		Gravel / silty sand
					2		iron stained ~~silty~~ sand mica silt low plastic(?)
							rounded gravel
					3		Gravel w. sand colluvium slightly moist.
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

colluvium

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________

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Test Boring Log

155 Monroe Avenue NE, Bldg D
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Phone 206/296-7709
Fax 206/296-0179

Project: Dockton	Elev.:	Job No.:	Boring KC-HK-DKR-05
		Drilling Method:	
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 11:56	Stop Time:	Date: 3-13- By:	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition: Sandy w/ small gravel beach
							Predominantly sand w/shell
					1		15"
					2	19"	gravel w/sand
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________.

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Test Boring Log

Project:	Elev.:	Job No.:	Boring 6
		Drilling Method: shovel	
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: Stop Time:		Date: By:	1 of

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition leaf litter on slope
					1		horizontal shovel pit into base of slope above ditch
					2		wet weathered Till gravel w/ gray "gley" plastic
					3		silt & clay
					4		1' depth
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________.

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Test Boring Log

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Phone 206/296-7709
Fax 206/296-0179

Project: Dockter	Elev.:	Job No.:	Boring 7
		Drilling Method: Chore	
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 145	Stop Time: 149	Date: 3-13 By: J Turney	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition
						2"⌀	shell, sand w/ gravel over
					1		rounded cobble w/ - sand
							caving
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________

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Test Boring Log

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Project:	Elev.:	Job No.:	Boring 8
		Drilling Method: Post hole digger	
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet 1 of 1
Start Time: 1:55	Stop Time: 2:00	Date: 3-13 By: JT	

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition Beach north
							sand shell & cobble ~ 3"
					1		then cobble w/sand & shell to .75
					2		sea creatures - worms & "straws"
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________.

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Test Boring Log

Project: Dockton Road	Elev.: GPS	Job No.:	Boring
		Drilling Method: Post hole - Surface Mapping	KG-1411 DKR-9
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 2 35 pm Stop Time: 300		Date: 3-13-09 By Turney	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition: Landslide - hydroseeded
					1		laminated very fine sand, silt w/ exposed
						ML-	upper 3rd of slide
					2	SM	oxidised layers
							Lake Deposit
					3		
							lower part fine med sand - no structure
					4		slide deposit? similar to 11
					5		upper laminated sediments seem very moist
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at ________ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________

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Test Boring Log

Project: Dockton	Elev.: GPS	Job No.:	Boring: KC-HH DKR-10
		Drilling Method: Posthole - e Bar	
Drilling Contr.:		Sampling Method: "cuttings"	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 2 34 Stop Time: 2:40		Date: 3-13-09 By: J Turney	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition: slope w/ ~~leaf~~ litter grass
					1	SW	Topsoil w/ Roots Brn sandy
							"Driller notes easy digging"
					2	SW	clean fine sand
							Probe to 4' no gravel no water
					3		
					4		
					5		soft. able to drive full bar length Dry no water.
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at _______ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ______________________.

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Materials Laboratory

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Phone 206/296-7709
Fax 206/296-0179

Test Boring Log

Project:	Elev.:	Job No.:	Boring
		Drilling Method: Posthole , bar	11
Drilling Contr.:		Sampling Method:	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 2:05 Stop Time: 210		Date: 3-13 By: JT	of

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition
						[illegible] 6"	coarse grey sand w/ small gravel
					1		soil to 3'8" - Bar easily pushed
							in to 3'8" dept
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at _______ feet below existing grade. Groundwater encountered at (NO groundwater encountered) ________ during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with ________________.

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King County
Dept. of Transportation
Materials Laboratory

No GPS

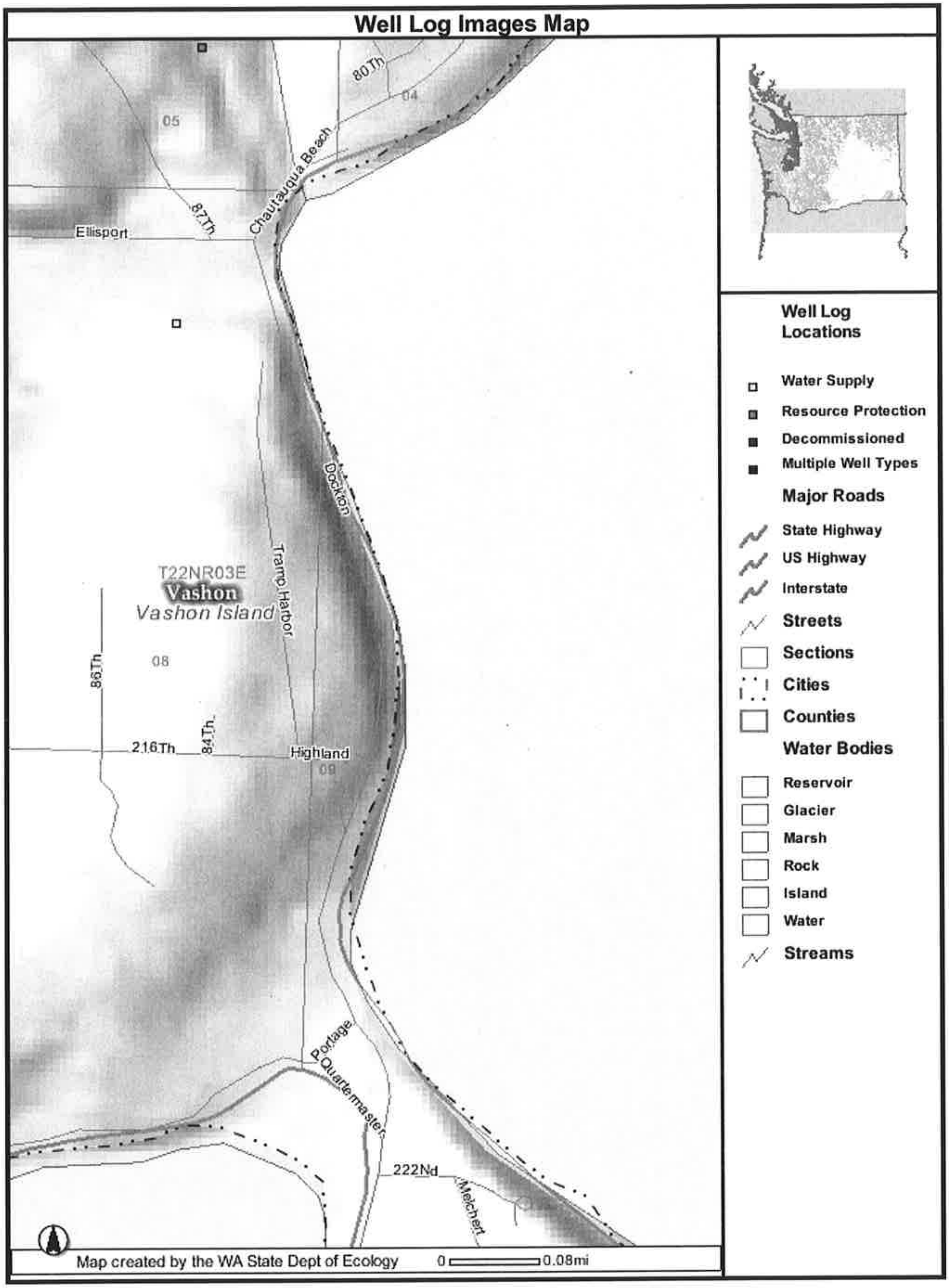
155 Monroe Avenue NE, Bldg D
Renton, WA 98056-4199
Phone 206/296-7709
Fax 206/296-0179

Test Boring Log

Project: Docktan	Elev.:	Job No.:	Boring KC-HH-DKR-12
		Drilling Method: Posthole & Bar	
Drilling Contr.:		Sampling Method: Cuttings	
Drilling Oper.:		Hammer Wt.: Drop:	Sheet
Start Time: 2 28	Stop Time: 2 33	Date: 3-13-09 By: J. Turney	1 of 1

Core Recovery	Sample Type	Sample No	Blows	N value	Depth in Feet	USCS Code	Surface Condition: Beach near culvert
					1	▽ 7"	easy digging sand w/ shells minor gravel
					2		shrimp, pile worm Bar pushed in 2.7' easily
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

Boring terminated at 18" feet below existing grade. Groundwater encountered at (NO groundwater encountered) 7" during drilling. 0.75-inch PVC standpipe installed to (bottom of boring) ________. Lower ________ feet slotted. Boring backfilled with native material.


Well Log Images Map
80Th
04
05
Chautauqua Beach
87Th
Ellisport
Dockton
T22NR03E
Vashon
Vashon Island
Tramp Harbor
86Th
08
216Th
84Th
Highland
09
Portage
Quartermaster
222Nd
Melchert
Map created by the WA State Dept of Ecology
0
0.08mi
Well Log Locations
Water Supply
Resource Protection
Decommissioned
Multiple Well Types
Major Roads
State Highway
US Highway
Interstate
Streets
Sections
Cities
Counties
Water Bodies
Reservoir
Glacier
Marsh
Rock
Island
Water
Streams

S.C. 007452

2213-8A

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 11797
Permit No

(1) OWNER: Name KING CO. WATER DIST. 19 Address VASHON IS. WA.

(2) LOCATION OF WELL: County KING — NE ¼ NE ¼ Sec. 8 T 22N N., R 3E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) PLANT 2
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 270 ft. Depth of completed well 270 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 250 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 36 ft.
Material used in seal GROUT IN 12x8"
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 4 ft. below top of well Date 3/89
Artesian pressure lbs. per square inch Date
Artesian water is controlled by WELDED CAP SURFACE SEAL (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

KING 270'

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
BRN. GRAY SAND GRVL	0	13
BLUE SILT SAND GRAVEL W/H2O	13	15
GRAY SILT SAND GRAVEL W/H2O	15	170
" " CLAY SOME GRAVELS	170	270
DRY WELL TO BE DEEPENED IN FUTURE W/ROTARY RIG.		

Plot in center of King Co. parcel
KT

MAY 19 1989

Work started 2 3 1989. Completed 3 3, 1989

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME MATHEWS WELL DRILLING (Person, firm, or corporation) (Type or print)

Address 1256 NW COMYN RD POULSBO WA.

[Signed] Jon C Math (Well Driller)

License No. 1137 Date 3/30, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20


Qva
ROBINSON ED
KIM TAYOR & GAIL LABIN SKY
HENRY SAVER
JIM ELLINGTON
KING Co WATER DISTRICT # 19
KING Co WATER DIST 19
water
CARROLL WILLIAM
Qvt
HAMMETT ROGER
JIM OBRIAN
CAPP, ALAN
Qva
WILSON CHARLES
N
water
af
Qva
Qf
Qpf
RON MITCHELL JIM STEWART
Qoal
Qpff
water
Qvt
water
0
320
640
1,280
1,920
2,560
Feet

EQUIS_ID	Name	Depth	Depth	Material Log
V_472433122264501	CAPP, ALAN	0	35	BROWN GRAVELLY HP
V_472433122264501	CAPP, ALAN	35	52	BROWN SANDY HP
V_472433122264501	CAPP, ALAN	52	68	BROWN GRAVELLY HP
V_472433122264501	CAPP, ALAN	68	75	BROWN SAND
V_472434122244301	WILSON CHARLES	0	30	BROWN CLAY
V_472434122244301	WILSON CHARLES	30	90	BROWN HARDPAN
V_472434122244301	WILSON CHARLES	90	94	SANDY HARDPAN
V_472434122244301	WILSON CHARLES	94	95	SAND
V_472434122244301	WILSON CHARLES	95	100	BROWN SILT & SAND
V_472434122244301	WILSON CHARLES	100	106	BROWN SAND
V_472447122244302	HAMMETT ROGER	0	11	OVERBURDEN
V_472447122244302	HAMMETT ROGER	11	24	GRAY GRAVELLY HARDPAN
V_472447122244302	HAMMETT ROGER	24	49	BROWN HARDPAN
V_472447122244302	HAMMETT ROGER	49	56	GRAY SAND W BINDER
V_472447122244302	HAMMETT ROGER	56	73	BROWN SAND W BINDER
V_472447122244302	HAMMETT ROGER	73	80	SAND & GRAVEL W WATER
V_472447122244302	HAMMETT ROGER	80	88	SILTY SAND
V_472447122264401	CARROLL WILLIAM	0	2	TOPSOIL
V_472447122264401	CARROLL WILLIAM	2	44	GRAY TILL COMPACT
V_472447122264401	CARROLL WILLIAM	44	65	BROWN SANDY CLAY
V_472447122264401	CARROLL WILLIAM	65	80	GRAY CLAY
V_472447122264401	CARROLL WILLIAM	80	95	GRAY SANDY CLAY
V_472447122264401	CARROLL WILLIAM	95	120	GRAY SANDY TIGHT
V_472447122264401	CARROLL WILLIAM	120	126	CLEANER FINE SAND
V_472457122262201	KC WATER DIST 19	0	13	BROWN GRAY SAND & GRAVEL
V_472457122262201	KC WATER DIST 19	13	15	BLUE SILT SAND GRAVEL W WATER
V_472457122262201	KC WATER DIST 19	15	170	GRAY SILT SAND GRAVEL W WATER
V_472457122262201	KC WATER DIST 19	170	270	GRAY SILTY CLAY SOME GRAVEL
V_472500122262501	KC WATER DIST 19	0	13	BROWN GRAY SAND AND GRAVEL
V_472500122262501	KC WATER DIST 19	13	15	BLUE SILT SAND GRAVEL W/WATER
V_472500122262501	KC WATER DIST 19	15	170	GRAY SILT SAND GRAVEL WATER
V_472500122262501	KC WATER DIST 19	170	270	GRAY SILT CLAY SOME GRAVEL

Appendix B

Seismic Data Magnitude 3.0 or Greater

Your search parameters are:

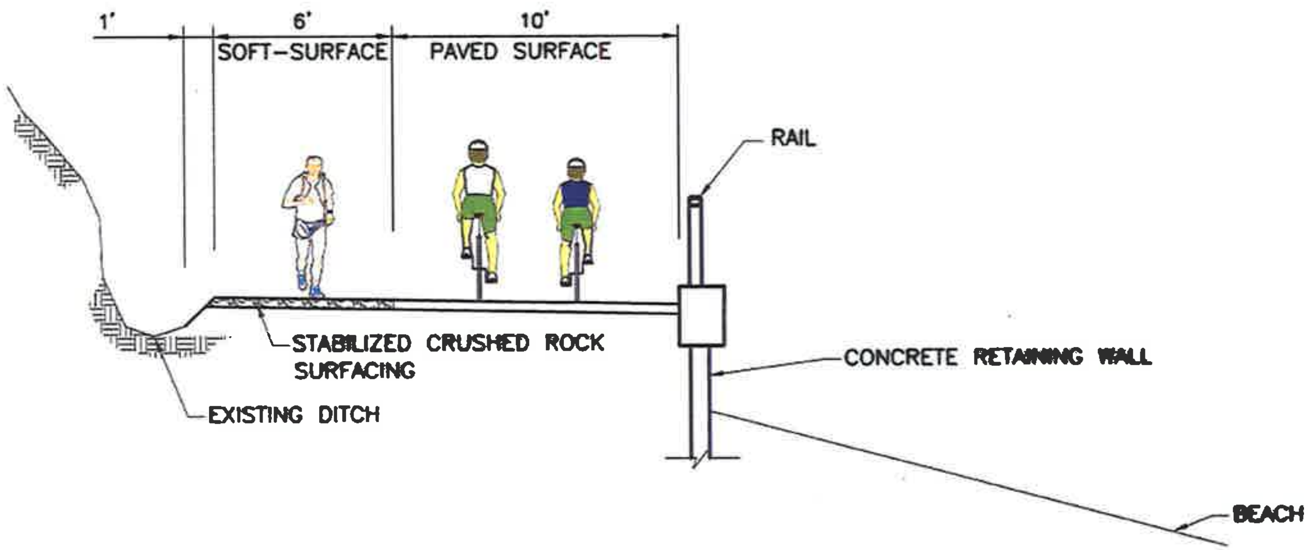
- catalog=ANSS
- start_time=1898/01/01,00:00:00
- end_time=2009/03/11,00:00:00
- minimum_latitude=47.1
- maximum_latitude=47.7
- minimum_longitude=-122.8
- maximum_longitude=-122.2
- minimum_magnitude=3.0
- maximum_magnitude=10
- event_type=E

Date	Time	Lat	Lon	Depth	Mag	Magt	Nst	Gap	Clo	RMS	SRC
1965/04/29	15:28:43.30	47.4000	-122.4000	57.00	6.88	Unk	114			0.00	NEI
1965/10/23	16:27:59.80	47.5000	-122.4000	23.00	4.80	Mb	13			0.00	NEI
1967/01/18	06:58:20.40	47.3000	-122.5710	22.00	3.60	Mb	7			0.00	NEI
1971/06/24	02:26:53.53	47.5847	-122.2048	19.04	3.30	Mc	9	194	4	0.19	UW
1971/06/25	13:45:40.70	47.5675	-122.2247	20.10	3.00	Mc	7	190	2	0.15	UW
1971/06/26	22:02:15.08	47.5712	-122.2155	21.15	3.30	Mc	7	191	2	0.12	UW
1971/08/10	20:26:48.40	47.5827	-122.2087	20.06	3.10	Mc	7	164	4	0.17	UW
1971/09/09	20:32:59.25	47.5688	-122.2177	20.56	3.50	Mc	8	160	2	0.16	UW
1971/12/28	07:50:00.87	47.5748	-122.2092	21.35	4.10	Mc	8	95	3	0.09	UW
1971/12/30	14:32:18.35	47.6090	-122.7297	12.68	3.20	Mc	8	125	8	0.14	UW
1972/01/13	22:06:16.94	47.3108	-122.6002	45.80	3.60	Mc	8	104	29	0.11	UW
1972/02/22	12:35:05.74	47.3315	-122.7620	5.27	3.40	Mc	11	132	24	0.18	UW
1972/04/29	11:42:31.23	47.6268	-122.4327	24.02	3.00	Mc	11	80	16	0.11	UW
1972/10/22	09:16:28.79	47.5777	-122.2040	20.98	3.40	Mc	9	96	4	0.13	UW
1972/11/03	11:57:58.66	47.5695	-122.7358	18.03	3.00	Mc	10	102	4	0.10	UW
1972/12/03	10:17:42.41	47.4808	-122.7575	15.64	3.60	Mc	9	136	7	0.19	UW
1973/02/06	22:56:00.07	47.4873	-122.5500	46.64	3.00	Mc	11	72	19	0.09	UW
1973/10/07	13:53:10.90	47.6095	-122.3255	2.64	3.30	Mc	10	88	8	0.16	UW
1973/11/03	16:22:01.72	47.6027	-122.3245	4.91	3.00	Mc	11	87	8	0.24	UW
1975/07/14	05:50:35.43	47.3192	-122.3938	7.88	3.40	Mc	15	74	28	0.25	UW
1975/07/24	11:42:12.76	47.3332	-122.4065	7.87	3.40	Mc	14	75	27	0.29	UW
1976/01/05	13:25:44.13	47.4710	-122.5980	42.16	3.30	Mc	10	84	16	0.16	UW
1978/03/11	15:52:11.86	47.4200	-122.7095	22.30	4.80	Mc	19	61	15	0.28	UW
1978/03/31	08:03:00.74	47.4172	-122.7107	21.13	4.10	Mc	19	61	15	0.26	UW
1978/06/20	14:40:21.40	47.5450	-122.7072	46.04	3.30	Mc	17	48	5	0.23	UW
1980/04/27	06:00:27.61	47.3745	-122.5570	20.18	3.70	Mc	24	48	25	0.13	UW
1980/05/06	08:28:49.47	47.3750	-122.5513	19.46	3.00	Mc	24	57	26	0.12	UW
1980/06/23	16:05:16.43	47.5427	-122.2508	0.05	3.70	Mc	18	54	1	0.16	UW
1980/06/23	16:09:55.04	47.5405	-122.2477	0.02	3.30	Mc	22	54	1	0.24	UW
1981/01/23	16:46:47.79	47.6003	-122.4163	22.61	3.00	Mc	32	43	13	0.08	UW
1981/11/26	12:30:01.08	47.6460	-122.6222	21.95	3.50	Mc	33	35	16	0.15	UW
1982/04/14	07:22:43.63	47.6328	-122.5168	27.28	3.40	Mc	29	56	22	0.10	UW
1982/10/15	09:56:35.86	47.5560	-122.5767	27.52	3.00	Mc	33	53	15	0.14	UW
1984/06/02	12:57:20.99	47.4145	-122.7022	21.49	3.60	Mc	35	26	16	0.22	UW
1985/02/28	17:02:04.40	47.4927	-122.5860	47.08	3.70	Mc	45	34	16	0.30	UW
1985/03/18	17:15:55.26	47.3388	-122.6198	53.30	3.50	Mc	43	43	15	0.28	UW
1985/03/21	02:39:21.70	47.6075	-122.2032	7.86	3.00	Mc	30	46	6	0.11	UW
1985/09/14	06:24:24.66	47.3905	-122.3833	19.85	3.00	Mc	51	34	20	0.14	UW
1988/03/11	10:01:26.04	47.1907	-122.3222	64.72	3.90	Mc	48	35	16	0.16	UW
1989/02/21	06:48:21.66	47.3235	-122.4600	15.97	3.00	Mc	56	30	19	0.21	UW
1989/06/18	20:38:37.39	47.4097	-122.7758	44.75	4.40	Mc	54	25	15	0.31	UW
1990/03/17	08:39:36.82	47.3232	-122.3007	6.77	3.00	Mc	59	31	25	0.15	UW

1990/07/27	22:00:35.54	47.6387	-122.4828	22.28	3.00	Mc	35	32	13	0.11	UW
1991/07/25	01:46:46.00	47.4583	-122.6083	24.61	3.20	Mc	55	30	16	0.25	UW
1992/01/18	07:52:41.68	47.4032	-122.7087	13.84	3.10	Mc	43	30	17	0.15	UW
1993/01/26	17:05:49.68	47.3675	-122.6880	23.08	3.00	Mc	59	33	18	0.28	UW
1995/01/06	19:12:28.37	47.2880	-122.6907	45.95	3.10	Mc	43	51	10	0.16	UW
1995/01/29	03:11:22.68	47.3867	-122.3638	15.83	5.00	Mc	52	23	20	0.17	UW
1995/07/15	14:36:18.64	47.6240	-122.2015	24.98	3.00	Mc	60	31	8	0.14	UW
1997/02/10	04:26:58.06	47.5533	-122.2995	6.77	3.50	Mc	54	40	2	0.16	UW
1997/06/23	19:13:27.01	47.5983	-122.5703	13.50	4.90	Mc	55	20	17	0.19	UW
1997/06/23	21:46:24.45	47.6022	-122.5555	0.86	3.10	Mc	71	39	18	0.20	UW
1997/06/27	05:30:49.25	47.6053	-122.5858	1.54	3.10	Mc	66	41	16	0.39	UW
1997/06/27	10:47:49.00	47.5800	-122.5500	0.90	3.90	Mc	17			0.00	SEA
1997/07/11	01:28:55.32	47.5893	-122.5428	6.10	3.50	Mc	48	39	18	0.21	UW
1998/02/12	00:15:39.38	47.6728	-122.4972	29.78	3.00	Mc	55	50	11	0.28	UW
1998/11/03	22:40:48.57	47.5275	-122.7700	23.40	3.10	Mc	54	47	2	0.18	UW
1999/01/04	15:10:37.50	47.2022	-122.2770	22.17	3.20	Mc	72	33	9	0.32	UW
1999/07/02	05:22:19.30	47.3685	-122.3992	27.08	3.10	Mc	72	26	12	0.33	UW
2001/02/28	18:54:32.83	47.1490	-122.7267	51.90	6.80	Mc	66	31	8	0.20	UW
2001/03/01	09:10:20.93	47.1970	-122.7133	54.31	3.40	Mc	86	31	5	0.27	UW
2003/05/30	03:50:07.90	47.4895	-122.7285	25.01	3.70	Mc	89	55	3	0.19	UW
2003/07/06	05:55:11.30	47.4242	-122.7768	8.16	3.00	Mc	100	70	8	0.50	UW
2004/01/16	08:18:18.09	47.5692	-122.5902	55.63	3.60	Mc	92	17	3	0.30	UW

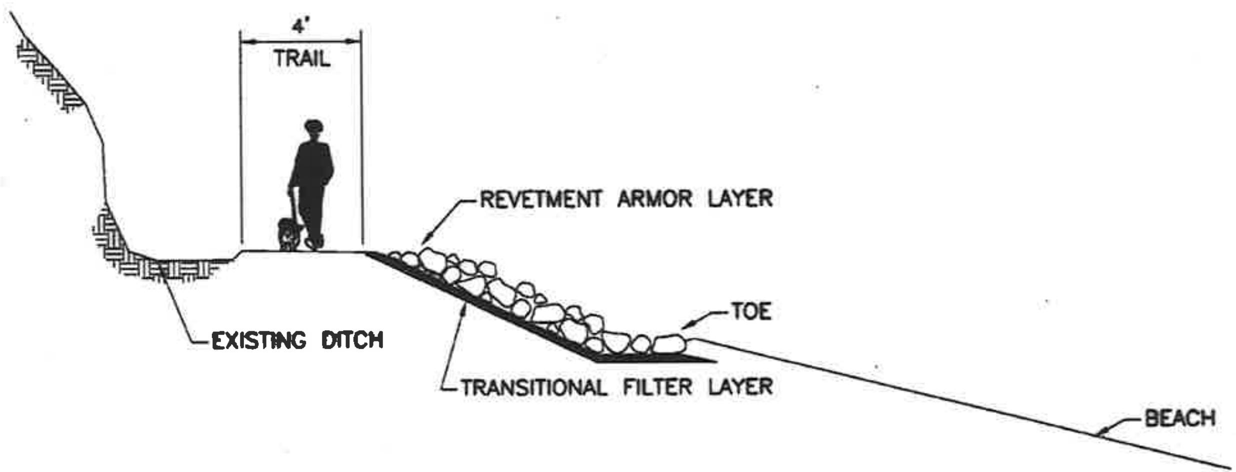
Appendix C

Alternative Figures



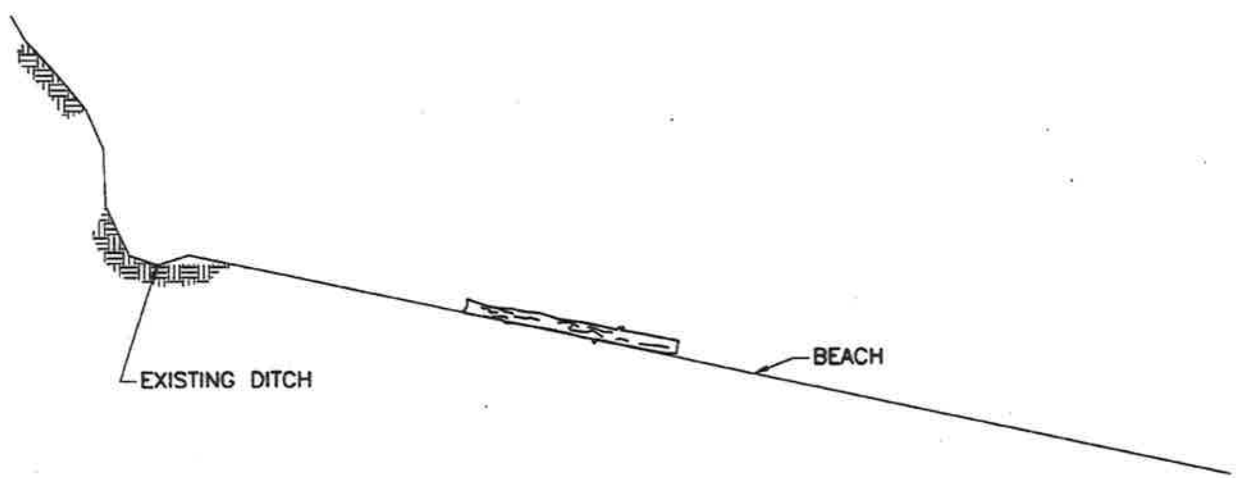
ALTERNATIVE 1: MIXED USE TRAIL WITH PARTIALLY EXPANDED BEACH

NTS



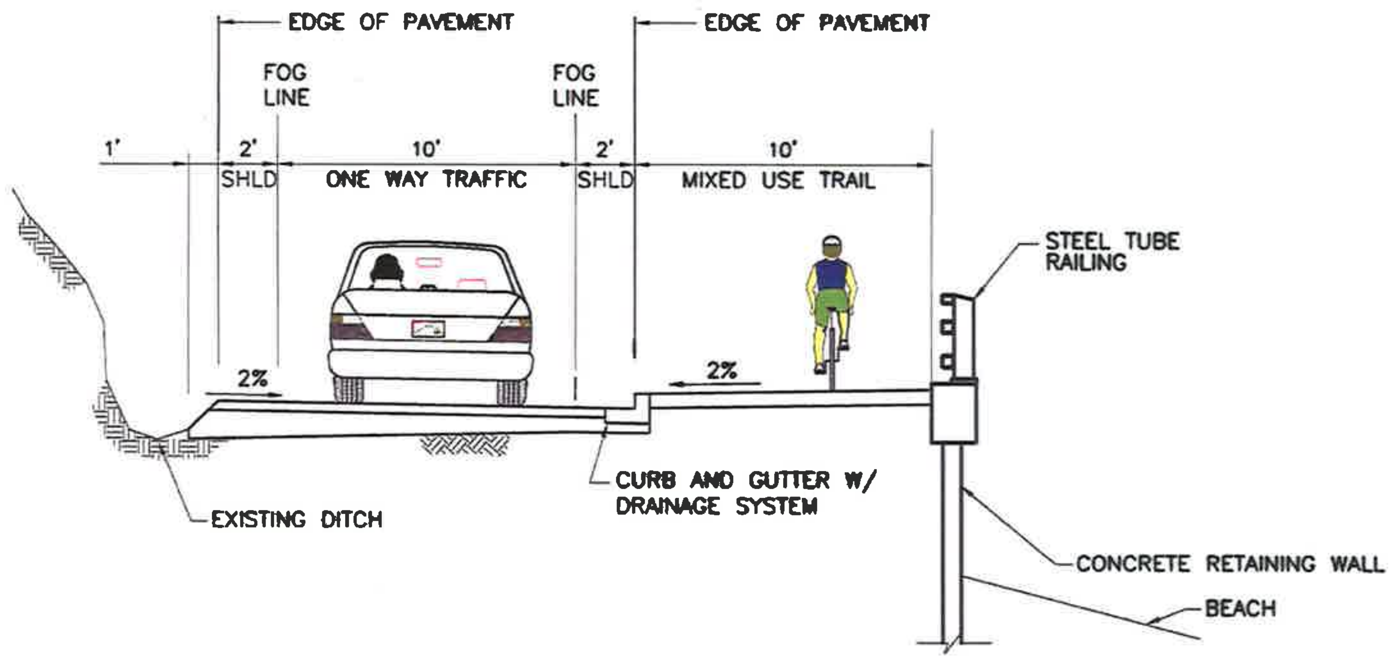
ALTERNATIVE 2: WALKWAY WITH EXPANDED BEACH

NTS



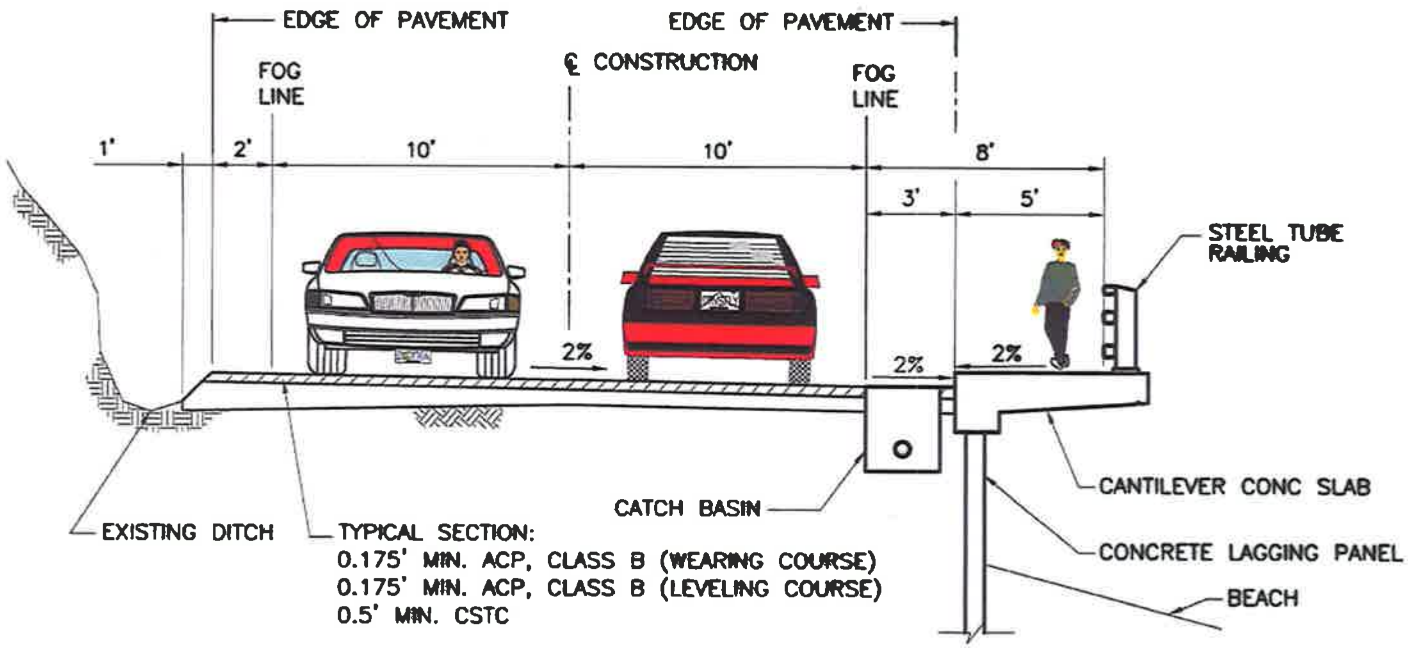
ALTERNATIVE 3: NATURAL UNDISTURBED BEACH

NTS



ALTERNATIVE 4: ONE WAY ROAD WITH 10-FOOT SIDEWALK

NTS



ALTERNATIVE 5: TWO LANE ROAD WITH CANTILEVERED SIDEWALK

NTS